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MINING AND MILLING METHODS AND COSTS IN THE ALMA DISTRICT, COLORADO

BY

Jos. R. Guiteras

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

MINING AND MILLING METHODS AND COSTS IN THE ALMA DISTRICT, COLORADO [1]

By Jos. R. Guiteras [2]

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INTRODUCTION

This paper is one of a series published by the Bureau of Mines on mining and milling methods and costs. It describes operations in the Alma district of Colorado in September 1937, supplemented by some additional data collected in July 1938.

ACKNOWLEDGMENTS

The author wishes to express his appreciation of the friendly cooperation extended him by the mine operators in the district. The greater part of the information was obtained from mine and mill superintendents to whom individual acknowledgment is made in the text.

THE ALMA DISTRICT

Situation

Alma is a mining town of a few hundred inhabitants in the northwest corner of Park County; it is about 10,240 feet above sea level. The Alma district is a designation loosely applied to the mining region roughly centered about the town of Alma. It lies wholly within Park County and comprises a group of mining districts extending south from the northern boundary of the county at Hoosier Pass to the vicinity of Fairplay, the county seat. Fairplay is about 90 miles southwest of Denver via highway U. S. 285 and about 86 miles northwest of Colorado Springs via highways U. S. 24 and Colorado 9. Alma is 5.6 miles northwest of Fairplay.

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Topography

The Alma district comprises a mountainous area within which altitudes range from 10,000 feet at Fairplay to 14,284 feet at the top of Mount Lincoln. The meadow known as South Park borders the area on the east, and the Mosquito Range forms the western boundary. The district extends roughly from the Continental Divide on the north to Sheep Mountain on the south. Figure 1 shows the general features of the district and the approximate situations of the mines that were active in September 1937.

Climate[3/]

The nearest station of the United States Weather Bureau to Alma is at Breckenridge, 18 miles north of Alma, at an elevation 9,536 feet above sea level. The average annual precipitation at Breckenridge for a 25-year period ended in 1913 was 23.93 inches. Precipitation was greatest during the spring and in July and August; it was least in June and during the fall. Average annual snowfall during a 20-year period was 184.8 inches.

The average annual temperature at Breckenridge for a 19-year period was 33.4° F.; the average maximum was 48.8° F., the average minimum 18.0° F. The highest average monthly temperatures during the period were 53° in July and August; lowest average monthly temperatures were 15° in December, January, and February. The highest recorded temperature was 90°; the lowest -40°.

History and Production

Henderson[4/] summarizes the early history of Park County, drawing largely from the annual reports of Raymond,[5/] Burchard,[6/] and others. Apparently placer mining had been conducted in a small way before 1860; about that time quartz lodes were first discovered. In 1871 discoveries of silver ores in the limestone formations on Mount Lincoln and Mount Bross gave prominence to the district. Considerable uncertainty existed as to whether those discoveries should have been preempted as lodes or placers. In that year the Moose mine on Mount Bross shipped silver ore valued at $460.00 per ton to Swansea, Wales. About that time placer operators replaced the old rocking methods by booming; quartz miners amalgamated their oxidized ores in arrastres. In December 1872 the Mount Lincoln Smelting Works started operations. Sulfide ores yielded lead "riches" and copper matte that were shipped to Germany. In 1873 discoveries of native silver were made in the Mosquito district. Ten years later the London mine in that district yielded

3/ U. S. Weather Bureau, Climatic Summary of the United States: Sec. 22 - Western Colorado, 1931.

4/ Henderson, C. W., Mining in Colorado: Geol. Survey Prof. Paper 138, 1926, pp. 186-195.

5/ Raymond, R. W., Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains for 1870 to 1875 (by years).

6/ Burchard, H. C., Report of the Director of the Mint upon the Production of the Precious Metals in the United States during the year 1880 to 1883 (by years).

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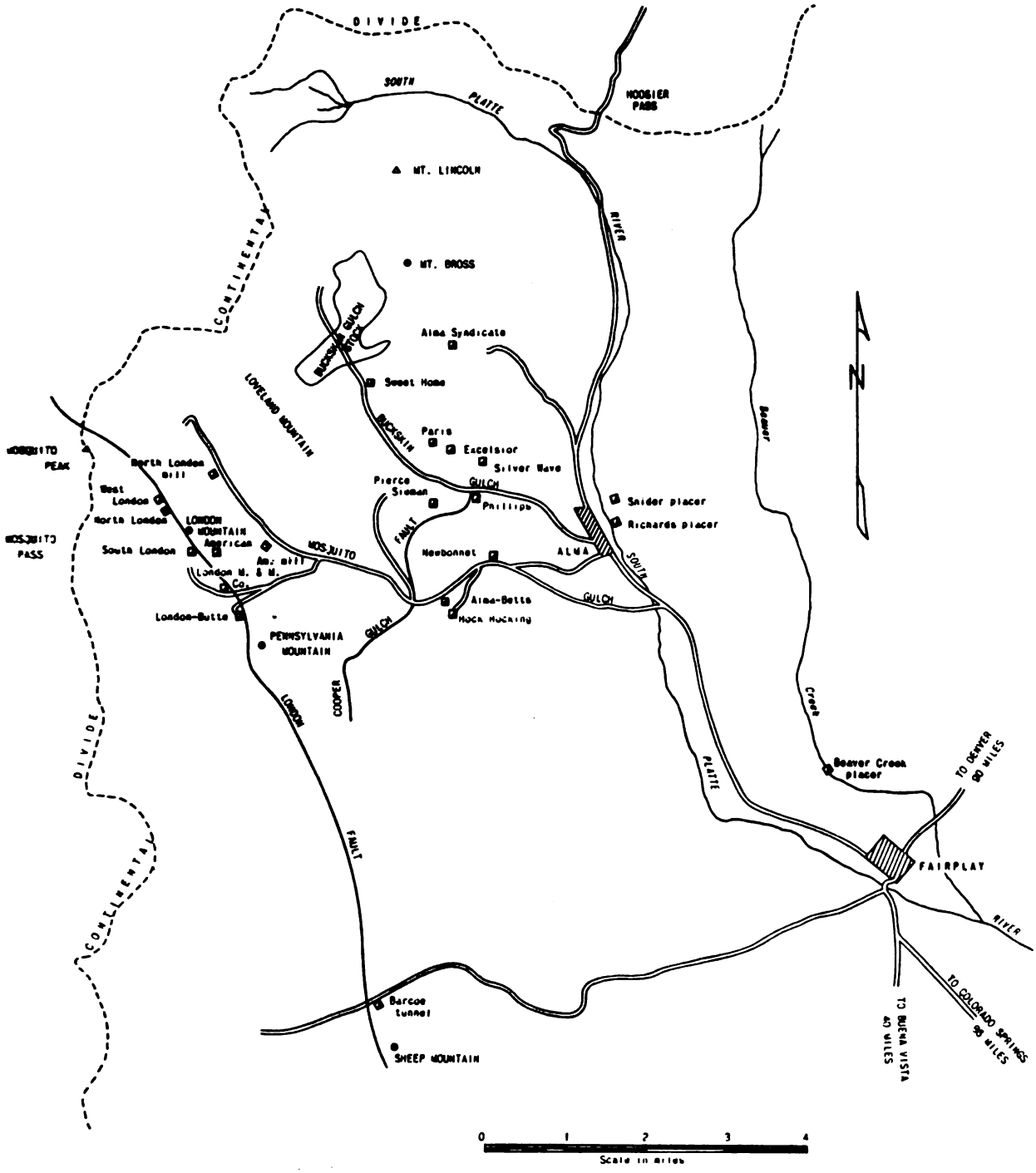

Figure 1.- Map of the Alma district, Colorado, showing the approximate locations of mines active in September 1937.

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a large proportion of the lode-gold production. To date the gold-quartz veins of the London Mountain area have produced about $20,000,000 worth of gold. The ebb and flow of production from the district can be seen readily in table 1. The lowest value of annual production in recent years was $44,857 in 1927, from which point the rise was spectacular, leveling off to all-time high figures for the depression years 1932-36. The zinc production from 1903 to 1916 was from the Horseshoe district.

Table 1 gives the total production of Park County for 1859-1936. In contributing the table, Henderson states:7/

> The Alma area may properly include all the east side of the Mosquito Range from Horseshow to Hoosier Pass, and the placer districts of Tarryall and South Platte; therefore, the Park County table can be said to represent closely the total production of the Alma area, for the outlying districts of Park County, namely, Hall Valley, Geneva Gulch, Guffy, Lake George, and Wilkinson, have produced less than 1 percent of the total of Park County.

Geology

The geology of the Alma district has been described by Singewald and Butler.8/ The following summary is taken largely from their works. The oldest rocks in the district are pre-Cambrian schists, mainly quartz-mica schists. Pre-Cambrian gneisses and granites are also present. The tops of the ridges are occupied by Paleozoic sedimentary rocks, which may be summarized as follows:

Weber (?) formation	Pennsylvanian
Blue limestone	Mississippian
Parting quartzite	Devonian
White limestone	Ordovician
Transition shales	Upper Cambrian
Sawatch quartzite	Cambrian

Tertiary intrusive rocks in the district include dikes, sills, and a stock. Most of the dikes occur in a northeast-trending belt about 3 miles wide. The sills are especially important near the base of the Weber (?) formation. The stock is in upper Buckskin Gulch (see fig. 1). Glaciation has removed most of the eroded material to the valleys beyond the limits of the district.

7/ Henderson, Chas. W., letter of transmittal.

8/ Singewald, Q. D., and Butler, B. S., Suggestions for Prospecting in the Alma District, Colorado: Proc. Colorado Sci. Soc., vol. 13, No. 4, 1933. Singewald, Q. D., and Butler, B. S., Structure and Mineralization along the London Fault, Colorado: Trans. Am. Inst. Min. and Met. Eng., vol. 126, 1937, p. 430.

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TABLE 1. - Gold (placer and lode), silver, copper, lead, and zinc produced in Park County, Colorado, 1859-1936, in terms of recovered metals.

Compiled by Chas. W. Henderson, Bureau of Mines, Mineral Production and Economics Division

Year	Ore treated short tons	Gold			Silver		
		Placer	Lode	Total	Fine ounces	Average price per ounce	Value
1859-1867.	-	$ 1,780,000	$ 710,000	$ 2,490,000	-	-	-
1868.....	-	1/50,000	-	50,000	-	-	-
1869.....	-	1/40,000	-	40,000	-	-	-
1870.....	-	40,000	40,000	80,000	-	-	-
1871.....	-	1/40,000	-	40,000	1/15,094	$ 1.325	$ 20,000
1872.....	-	1/50,000	-	50,000	1/142,209	1.322	188,000
1873.....	-	1/60,000	1/20,000	1/80,000	1/307,633	1.297	399,000
1874.....	-	66,497	50,000	116,497	333,764	1.278	426,550
1875.....	-	1/80,000	1/24,302	1/104,302	412,022	1.24	510,907
1876.....	-	1/40,000	1/20,000	1/60,000	1/386,719	1.16	448,594
1877.....	-	1/40,000	1/20,000	1/60,000	1/309,375	1.20	371,250
1878.....	-	1/40,000	1/20,000	1/60,000	1/309,375	1.15	355,781
1879.....	-	1/40,000	1/20,000	60,000	324,844	1.12	363,825
1880.....	-	1/30,000	1/20,000	50,000	293,906	1.15	337,992
1881.....	-	1/25,000	1/25,000	50,000	270,703	1.13	305,894
1882.....	-	1/25,000	1/75,000	100,000	193,359	1.14	220,429
1883.....	-	1/20,000	1/180,000	200,000	135,352	1.11	150,241
1884.....	-	1/30,000	1/30,000	60,000	193,359	1.11	214,628
1885.....	-	1/30,000	1/30,000	60,000	71,310	1.07	76,302
1886.....	-	1/30,000	1/118,284	148,284	71,310	.99	70,597
1887.....	-	1/190,000	1/458,462	648,462	107,513	.98	105,363
1888.....	-	1/23,000	1/10,945	33,945	450,457	.94	423,430
1889.....	-	1/42,000	1/82,745	124,745	224,743	.94	211,258
1890.....	-	1/23,611	1/13,670	37,281	156,975	1.05	164,824
1891.....	-	1/34,333	1/16,000	50,333	185,200	.99	183,348
1892.....	-	1/10,000	1/29,687	39,687	43,792	.87	38,099
1893.....	-	1/30,000	1/79,845	109,845	62,350	.78	48,633
1894.....	-	1/40,000	1/57,358	97,358	43,817	.63	27,605
1895.....	-	1/30,000	1/101,761	131,761	46,658	.65	30,328
1896.....	-	1/25,000	1/112,109	137,109	117,095	.68	79,625
1897.....	-	1/19,000	1/134,619	153,619	199,945	.60	119,967
1898.....	-	1/ 7,000	1/152,490	159,490	198,711	.59	117,239
1899.....	-	1/20,000	1/133,041	153,041	72,137	.60	43,282
1900.....	-	1/18,000	1/98,558	116,558	43,138	.62	26,746
1901.....	-	1/18,000	1/78,322	96,322	69,175	.60	41,505
[illegible]	-	[illegible]	[illegible]	142,458	49,968	.53	26,483

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Compiled by Chas. W. Henderson, Bureau of Mines, Mineral Production and Economics Division

Year	Lead			Copper			Zinc			Total value
	Pounds	Average price per pound	Value	Pounds	Average price per pound	Value	Pounds	Average price per pound	Value	
1859-1867.	-	-	-	-	-	-	-	-	-	$ 2,490,000
1868.....	-	-	-	-	-	-	-	-	-	50,000
1869.....	-	-	-	-	-	-	-	-	-	40,000
1870.....	-	-	-	-	-	-	-	-	-	80,000
1871.....	1/2/5,000	$0.06	$ 300	-	-	-	-	-	-	60,300
1872.....	1/750,000	.064	3,200	-	-	-	-	-	-	241,200
1873.....	1/111,400	.06	6,684	1/169,493	$0.28	$ 47,458	-	-	-	533,142
1874.....	-	-	-	1/203,391	.22	44,746	-	-	-	587,793
1875.....	1/25,000	.058	1,450	1/72,150	.227	16,378	-	-	-	633,037
1876.....	1/50,000	.061	3,050	1/68,333	.21	14,350	-	-	-	525,994
1877.....	1/150,000	.055	8,250	1/170,000	.19	32,300	-	-	-	471,800
1878.....	1/150,000	.036	5,400	1/175,000	.166	29,050	-	-	-	450,231
1879.....	1/300,000	.041	12,300	1/200,000	.186	37,200	-	-	-	473,325
1880.....	1/300,000	.05	15,000	1/200,000	.214	42,800	-	-	-	445,792
1881.....	1/312,000	.048	14,976	1/100,000	.182	18,200	-	-	-	389,070
1882.....	1/312,000	.049	15,288	1/100,000	.191	19,100	-	-	-	354,817
1883.....	1/312,000	.043	13,416	-	-	-	-	-	-	363,657
1884.....	1/398,065	.037	14,728	-	-	-	-	-	-	289,356
1885.....	398,066	.039	15,525	-	-	-	-	-	-	151,827
1886.....	1/624,000	.046	28,704	-	-	-	-	-	-	247,585
1887.....	708,713	.045	31,892	-	-	-	-	-	-	785,717
1888.....	7,641,720	.044	336,236	-	-	-	-	-	-	793,611
1889.....	4,640,682	.039	180,987	855	.135	115	-	-	-	517,105
1890.....	1,886,504	.045	84,893	-	-	-	-	-	-	286,998
1891.....	19,656	.043	845	-	-	-	-	-	-	234,526
1892.....	25,698	.04	1,028	-	-	-	-	-	-	78,814
1893.....	1/30,000	.037	1,110	1/10,000	.108	1,080	-	-	-	160,668
1894.....	1/30,000	.033	990	1/10,000	.095	950	-	-	-	126,903
1895.....	98,791	.032	3,161	2,938	.107	314	-	-	-	165,564
1896.....	297,714	.03	8,931	28,593	.108	3,088	-	-	-	228,753
1897.....	4,517,614	.036	162,634	58,002	.12	6,962	-	-	-	443,182
1898.....	1,953,001	.038	74,214	20,957	.124	2,599	-	-	-	353,542
1899.....	540,849	.045	24,338	7,903	.171	1,351	-	-	-	222,012
1900.....	682,107	.044	30,013	15,000	.166	2,490	-	-	-	175,807
1901.....	421,955	.043	18,144	9,657	.167	1,613	-	-	-	157,584
1902.....	261,046	.041	10,703	8,113	.122	990	-	-	-	180,634

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Compiled by Chas. W. Henderson, Bureau of Mines, Mineral Production and Economics Division

Year	Ore treated short tons	Gold			Silver		
		Placer	Lode	Total	Fine ounces	Average price per ounce	Value
1903.....	-	$ 1/12,000	$ 124,277	$ 136,277	52,128	$ .54	$ 28,149
1904.....	4,202	1/10,000	184,980	194,980	50,013	.58	29,008
1905.....	6,745	2,786	318,081	320,867	49,202	.61	30,013
1906.....	10,072	10,084	384,966	395,050	144,815	.68	98,474
1907.....	12,661	6,953	506,263	513,216	111,215	.66	73,402
1908.....	11,372	12,066	418,742	430,808	12,047	.53	6,385
1909.....	15,046	24,358	527,563	551,921	102,375	.52	53,235
1910.....	12,329	12,846	252,701	265,547	117,037	.54	63,200
1911.....	5,780	24,411	34,421	58,832	69,072	.53	36,608
1912.....	2,686	19,223	48,758	67,981	31,234	.615	19,209
1913.....	6,598	14,758	35,283	50,041	94,293	.604	56,953
1914.....	1,958	23,334	44,151	67,485	20,215	.553	11,179
1915.....	2,820	9,792	149,547	159,339	9,227	.507	4,678
1916.....	3,005	10,421	223,878	234,299	13,231	.658	8,706
1917.....	2,693	5,451	111,907	117,358	14,705	.824	12,117
1918.....	2,304	-	63,176	63,176	18,280	1.00	18,280
1919.....	11,210	4,135	125,422	129,557	70,949	1.12	79,463
1920.....	5,348	526	142,632	143,158	51,023	1.09	55,615
1921.....	4,929	429	40,821	41,250	47,547	1.00	47,547
1922.....	1,120	99,466	42,654	142,120	15,528	1.00	15,528
1923.....	471	144,468	16,974	161,442	18,701	.82	15,335
1924.....	5,602	113,548	25,783	139,331	16,906	.67	11,327
1925.....	1,123	23,672	29,164	52,836	15,657	.694	10,866
1926.....	3,489	127	37,146	37,273	7,835	.624	4,889
1927.....	1,928	299	39,420	39,719	3,913	.567	2,219
1928.....	2,918	-	254,699	254,699	8,684	.585	5,080
1929.....	3,791	-	206,797	206,797	8,953	.533	4,772
1930.....	5,134	100	452,042	452,142	11,709	.385	4,508
1931.....	11,497	108	871,681	871,789	28,531	.290	8,274
1932.....	42,157	3,460	2,596,017	2,599,477	63,220	.282	17,828
1933.....	62,643	6,301	1,531,039	1,537,340	40,526	.350	14,184
1934.....	128,977	68,403	2,932,671	3,001,074	61,510	.646+	39,764
1935.....	121,740	168,282	2,349,718	2,518,000	62,294	.71875	44,774
1936.....	120,425	116,690	1,852,662	1,969,352	50,302	.7745	38,959
Total to 1936 inc..	-	$ 4,048,938	$ 20,066,692	3/$24,115,630	7,334,885	-	7,118,253

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Compiled by Chas. W. Henderson, Bureau of Mines, Mineral Production and Economics Division

Year	Lead			Copper			Zinc			Total value
	Pounds	Average price per pound	Value	Pounds	Average price per pound	Value	Pounds	Average price per pound	Value	
1903.....	802,489	.042	$ 33,705	5,895	.137	$ 808	-	-	-	$ 198,939
1904.....	757,703	.043	32,581	5,920	.128	758	-	-	-	257,327
1905.....	543,303	.047	25,535	12,199	.156	1,903	-	-	-	378,318
1906.....	966,193	.057	55,073	14,399	.193	2,779	-	-	-	551,376
1907.....	1,062,732	.053	56,325	-	-	-	-	-	-	642,943
1908.....	495,985	.042	20,831	37,106	.132	4,898	728,000	$0.047	$34,216	497,138
1909.....	2,237,093	.043	96,195	61,023	.13	7,933	366,574	.054	19,795	729,079
1910.....	2,041,204	.044	89,813	88,748	.127	11,271	659,796	.054	35,629	465,460
1911.....	923,089	.045	41,539	24,216	.125	3,027	407,772	.057	23,243	163,249
1912.....	167,756	.045	7,549	10,321	.165	1,703	132,275	.069	9,127	105,569
1913.....	506,046	.044	22,266	29,161	.155	4,520	98,623	.056	5,523	139,303
1914.....	168,154	.039	6,558	8,023	.133	1,067	57,940	.051	2,955	89,244
1915.....	190,830	.047	8,969	12,303	.175	2,153	472,992	.124	58,651	233,790
1916.....	330,609	.069	22,812	22,598	.246	5,559	47,560	.134	6,373	277,749
1917.....	278,709	.086	23,969	12,824	.273	3,501	-	-	-	156,945
1918.....	233,873	.071	16,605	12,704	.247	3,138	-	-	-	101,199
1919.....	305,908	.053	16,213	20,436	.186	3,801	-	-	-	229,034
1920.....	1,085,625	.08	86,850	18,674	.184	3,436	-	-	-	289,059
1921.....	654,090	.045	29,434	7,550	.129	974	-	-	-	119,205
1922.....	155,982	.055	8,579	4,215	.135	569	-	-	-	166,796
1923.....	19,401	.07	1,358	5,558	.147	817	-	-	-	178,952
1924.....	110,062	.08	8,805	25,206	.131	3,302	20,000	.065	1,300	164,065
1925.....	77,500	.087	6,742	18,000	.142	2,556	2,000	.076	152	73,152
1926.....	48,500	.08	3,880	1,750	.14	245	-	-	-	46,287
1927.....	39,477	.063	2,487	3,298	.131	432	-	-	-	44,857
1928.....	163,724	.058	9,496	6,583	.144	948	-	-	-	270,223
1929.....	148,206	.063	9,337	1,693	.176	298	-	-	-	221,204
1930.....	328,800	.050	16,440	8,100	.130	1,053	-	-	-	474,143
1931.....	779,190	.037	28,830	21,198	.091	1,929	-	-	-	910,822
1932.....	1,615,000	.030	48,450	60,300	.063	3,799	-	-	-	2,669,554
1933.....	1,319,300	.037	48,814	82,000	.064	5,248	-	-	-	1,605,586
1934.....	2,625,800	.037	97,155	72,100	.080	5,768	-	-	-	3,143,761
1935.....	1,908,500	.040	76,340	92,000	.083	7,636	-	-	-	2,646,750
1936.....	1,634,000	.046	75,164	25,000	.092	2,300	-	-	-	2,085,775
Total to 1936 inc..	51,978,415	-	2,263,089	2,461,486	-	423,263	2,993,532	-	196,964	34,117,199

1/ Estimated by Chas. W. Henderson. 2/ Shipped to Swansea, Wales. 3/ Gold has been calculated, 1859-1932, $20.6781346; 1933, $25.56; 1934, $34.95; 1935-36, $35.00.

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The most prominent folds in the district have developed into reverse faults, the largest being the London. This fault strikes northwest and dips steeply to the northeast; it has been traced for over 20 miles (see fig. 1). At Pennsylvania Mountain its stratigraphic throw is estimated at 2,500 feet.

Almost all the ore produced in the Alma district has come from a northeast-trending zone that roughly corresponds to the belt of dikes mentioned above. The zone is included in a great mineral belt that extends from Leadville to Boulder.

Singewald and Butler9/ have classified the ores of the Alma district as follows:

Gold deposits:
- London type
- Quartzite replacement type
- Other types

Silver-lead deposits:
- Limestone replacement type
- Other types

Most of the ore deposits are associated with major structural features within the northeast-trending belt of dikes. The gouge in the London fault apparently acted as a dam to uprising mineralizing solutions, thus concentrating ore deposition on the footwall side. The Cooper Gulch fault, with little gouge, permitted solutions to penetrate into the hanging wall. The mineralization on Mount Bross and Mount Lincoln probably was localized by a structural terrace.

There are three main ore-producing horizons: (1) A zone of siliceous porphyry sills in the basal part of the Weber (?) formation, containing the gold ores of London Mountain; (2) the upper part of the Blue limestone, containing nearly all the silver-lead replacement deposits; and (3) the Sawatch quartzite, containing the gold and silver veins of lower Mosquito Gulch and lower Buckskin Gulch.

The most valuable deposits in the Alma district are the gold-quartz veins of the London type that occur in the London Mountain area. Most of the veins of that type occupy a porphyry zone 175 to 275 feet thick, the bottom of which is 10 to 20 feet above the bottom of the Weber (?) formation. The ore shoots roughly parallel the enclosing sedimentary strata on the west (footwall) side of the London fault. They are terminated by overlying shales on the west and by the gouge in the London-fault sheer zone on the east. The most nearly continuous group of veins in the district is in the London mine, along minor faults auxiliary to the London fault.

The quartz in the London veins is of a glassy, milky variety. In addition to free gold, the veins contain pyrite, galena, chalcopyrite, sphalerite and fragments of shale and porphyry.

9/ Singewald, Q. D., and Butler, B. S., work cited in footnote 8.

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Transportation

All shipments to and from Alma are made by truck; the Colorado & Southern R.R. has abandoned its line that formerly served the district. Hauling is done by a trucking company with headquarters in Alma.

Shipping ore and concentrates are hauled from mines and mills in the Alma district to Leadville via Buena Vista, a total distance of 80 miles. The usual load is 7 tons. In September 1937 about 40 tons of concentrates was hauled daily. The return trip is made via Dillon, which shortens the distance to 62 miles. The empty trucks must cross Fremont Pass (altitude, 11,316 feet) and Hoosier Pass (altitude, 11,541 feet), both of which are avoided by the longer route. The rate from Alma to Leadville ranges from $4.50 to $5.50 per ton, depending on the situation of the property. The same rate is charged for hauling supplies back from Leadville to the mines.

The cost of hauling freight from Denver to Alma ranges from $0.41 to $1.00 per hundred pounds, depending on the classification.

Coal is hauled to Alma from Buena Vista at $2.75 per ton.

The Alma-Fairplay Tailings-Disposal Project

In the summer of 1937 a project for a filtration dam across the South Platte River at Fairplay was submitted by the miners and ranchers of Park County, Colo., to the Mineral Resources Board of that State. The project was approved, and the dam was built under the direction of a committee appointed by the Board. According to a report by W. E. Scott, Jr., chairman of the Mineral Resources Board, the cost of the dam is shown in table 2.

The dam was paid for by issuing bonds. Before construction was begun, mine operators and business men had pledged $15,000. The miners agreed to impound on their own property as much of their tailings as reasonably possible. This implied holding back sands and slimes in the summer and sands in the winter, together with as much of the slimes as could be dropped by the individual dams. Some of the miners made provision for running their slimes out on the hillside behind their tailings dams in the winter. It was thought that the underbrush would hold back much of the fine material that otherwise would wash over the frozen pond.

To retire the bonds and to provide for maintenance of the dam, the operators of lode mines agreed to pay 4 cents per ton of tailings made and the operators of placer mines one-half cent per cubic yard of gravel worked. It was estimated that the mills in the district produced a total of 160,000 to 180,000 tons of tailings a year and that it would require about 4 years to pay for the dam. The dam, 600 feet long, was expected to fill up in about that time. The ranchers and other users of the water below the dam agreed to not bring suit against the miners during construction of the dam and as long as the water flowing past the dam contained not over 5 percent solids.

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TABLE 2. - Cost of Alma-Fairplay tailings-disposal project

Preliminary expenses:		
Ranchers' agreements, including recording	$ 346.59	
Miners' contracts	289.80	
Engineering, including maps	297.01	
Legal expense	404.85	
Office expense	135.00	
Printing bonds	98.50	
Purchase of land	1,500.00	$ 3,071.75
Preliminary construction:		
Clearing ground	$ 227.49	
Moving equipment	132.90	
Moving shacks	281.01	641.40
Dam construction:		
Equipment rental	$3,677.95	
Labor	3,018.62	
Trucking	1,276.63	
Fuel oil, oil and grease	220.74	
Repairs and supplies	94.18	
Supervision and executive expense	546.39	
Compensation insurance	122.61	
Watchman	15.00	8,972.12
Total cost	-	$12,685.27

Total excavation or total fill ..... cubic yards	31,600
Cost of excavation per cubic yard	28 cents
Time consumed in building dam .....working days	36
Average excavation per day ..... cubic yards	877

The completed dam appeared to be working successfully. Evidently the problem of stream pollution can be solved to the mutual satisfaction of miners and ranchers, and much credit is due to those who engineered the Alma-Fairplay project and carried it through to a successful conclusion.

LODE MINES

The London Mines & Milling Co.

The operations of the London Mines & Milling Co. are by far the largest in Park County. The mine is in the Mosquito mining district about 5 miles west of Alma. The ore bodies lie in the footwall of the London fault in London Mountain (see p. 10).

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The London ore body was discovered in 1872. Mining was begun in 1876 in what is now referred to as the "north side" workings and has been virtually continuous ever since. Later discoveries led to mining the "south side" ore bodies through the old South London adit, which is now part of the 500-foot level of the mine. Those operations were followed by mining through the present Extension tunnel. A concentration and amalgamation mill was operated on the north side until 1902, when it was shut down owing to the low recovery obtained. Mining by lessees continued until 1918.

The London Mines & Milling Co. was incorporated September 14, 1912, and operated the mine until 1921, when the property was leased to the London Gold Mines Co. with the understanding that the latter would drive the Extension tunnel 2,000 feet beyond the 1,200 feet already driven. About 1926 the Extension tunnel penetrated ore bodies in the south end of the mine, and a connection was made with the old south workings. During the next 6 years the mine prospered as a producer of high-grade ore. Sorting was done in the stopes and in a washing plant on the surface. The cleaned ore was shipped to the American Smelting & Refining Co. at Leadville and to the Golden Cycle mill at Colorado City. In the fall of 1932 a 60-ton concentrating mill was built on the present site; the capacity soon was increased to 100 tons. Concentrates were shipped to Leadville. The capacity of the mill has been increased gradually to its present 200 tons per day. In September 1937 the mine was working two shifts per day 6 days a week; the mill was working three shifts per day 7 days a week; a total of about 250 men was employed.

The information on the London Mines & Milling Co. that follows was kindly supplied by H. L. Tedrow, general superintendent, and his staff. Frank L. Kennicott, mine superintendent, contributed most of the mine data; and A. L. Pessin, mill superintendent, furnished the milling and metallurgical data. R. W. Jenkins, of the engineering staff, contributed the drawings and much of the technical detail.

Mine

The ore bodies at the London mine occur in veins of the fissure type; they are described on page 10. The veins persist, although there is much local pinching and swelling. Gold and silver values are contained in a sulfide ore. The principal sulfides are pyrite and galena; there are relatively small amounts of sphalerite and chalcopyrite. The gangue is mainly quartz with some porphyry and limestone. Native gold occurs finely disseminated through the pyrite and quartz. Most of the silver is in the galena.

There is a compressor house between the mine office and the mill, near the portal of a lower tunnel. It houses two compressors; an 1,875-cubic-foot compressor driven by a 300-horsepower-motor and a 490-cubic-foot compressor that is held in reserve. Air is supplied at a pressure of 100 pounds per square inch at the compressor. An 8-inch main line delivers the air to a 4- by 12-foot receiver 200 feet in the lower tunnel. From there a 6-inch line carries the air up a raise to the Extension tunnel, then to No. 8 raise, from which point a 4-inch line delivers the air to a 3-1/2- by 10-foot receiver at the Big raise. Two 4-inch air lines and a 3-1/2-inch line extend up the Big raise to the 500 level; 1-1/2-inch lines lead off to headings and stopes.

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Water for the compressors and for the camp supply is obtained from a spring a short distance up Mosquito Gulch.

Prospecting and Development.

Prospecting is done by drifts, crosscuts, and raises from the several levels and by waste raises from the stopes. An average of about 850 feet of prospect workings is driven each month. Considerable prospecting formerly was done by diamond drilling, and that method probably will be used to some extent in the future. Figure 2 shows a longitudinal section of the London mine.

Development consists of drifting on the vein, crosscutting, and raising; all development work is done on contract. The company furnishes everything but labor and pays the contractor $3.00 per foot for untimbered drifts and crosscuts 5 by 7 feet in section. If the broken rock must be trammed over 300 feet the price per foot is increased 25 cents for each additional 300 feet of tram. If timber is required the price is higher.

The usual method of driving drifts or crosscuts is to drill on the day shift and muck out at night. A round of 10 to 15 holes is drilled by one man, using a drifting machine mounted on a 6-1/2 foot vertical column. A bottom cut is usually drilled, but a V-cut or pyramid cut sometimes is used. A round requires about 60 sticks of 45-percent-strength gelatin dynamite and breaks 4-1/2 to 6 feet. Seven-foot fuses and No. 6 blasting caps are used. Figure 3 shows a drill round for the main tunnel. All raises are cribbed; they may be two- or three-compartment. Raise rounds are either end cut or V-cut.

Drifting machines use 1-1/8-inch round steel; stopers use 1-inch quarter-octagon steel. Detachable bits are employed. Starting bits usually are 2 inches in diameter, following sizes decrease by 1/8 inch, and finishers are 1-1/2 inches. In easy-drilling ground that requires only three or four "changes" of steel, smaller starting sizes are employed, thus using up the small bits that otherwise tend to accumulate. Bits are reground by the hoistman at the head of an incline from the office up to the Extension tunnel. For convenience in carrying, and to prevent loss, bits distributed to miners are mounted on rectangular plates of sheet steel. The sheets are provided with sockets for 15 or 20 bits on each side; they have a handle for carrying. The same bits are used for drifters, stopers, and jackhammers.

Water for drilling operations is obtained from a diamond-drill hole on the 300-foot level. A tank on the 400-foot level receives the water from the diamond-drill hole. The water is piped to the lower workings through a 1-1/2-inch line with 1/2-inch branch lines. Above the 400-foot level, 21-inch by 10-foot pressure tanks are used; they are filled from the tank on the 400-foot level.

Air circulates through the mine workings by natural ventilation.

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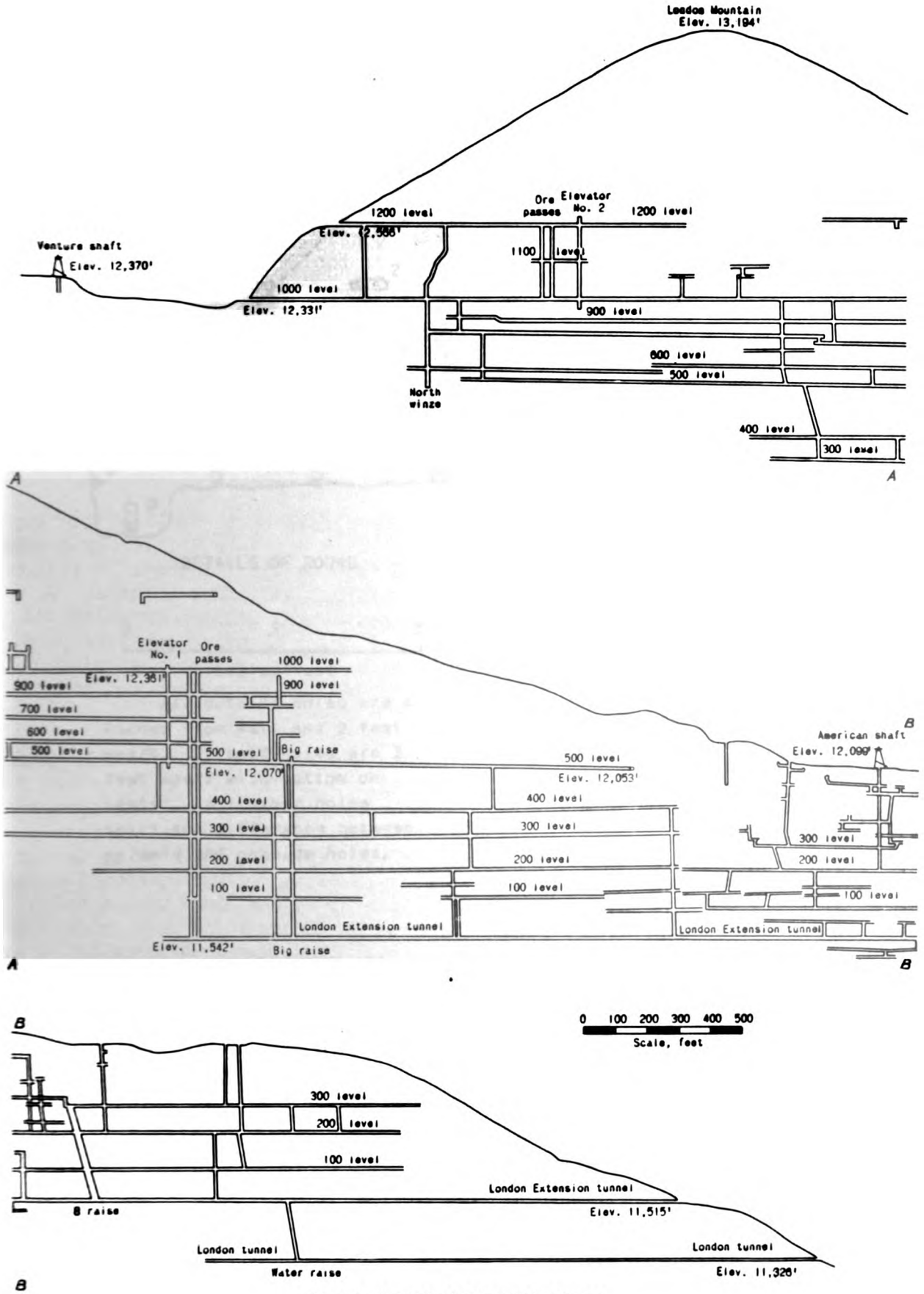

Figure 2.- Longitudinal section of London mine.

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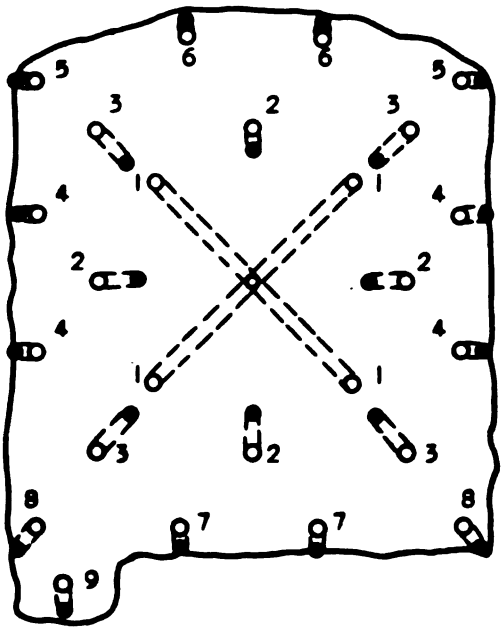
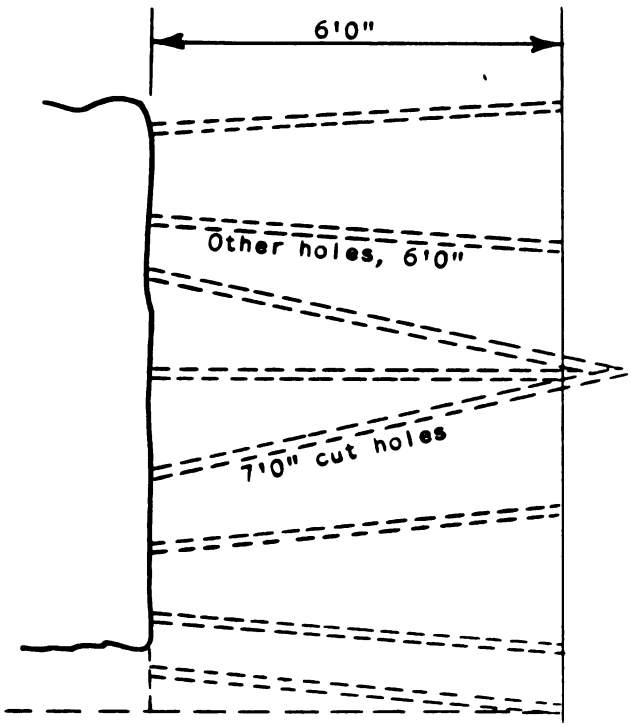


DETAILS OF ROUND

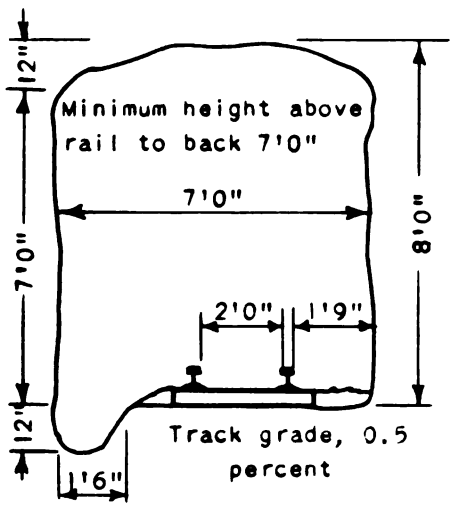


SIDE SECTION

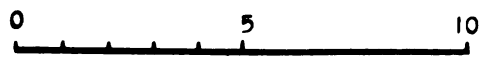
25 holes, 158 sticks of powder

Scale, feet

All outside holes are 4 inches from wall and 2 feet apart. Pyramid holes are 3 feet apart with bottom on center. All other holes split the difference between pyramid and outside holes.



SECTION THROUGH TUNNEL LOOKING NORTHWEST



Scale, feet

Figure 3.- Drill round for main tunnel heading.

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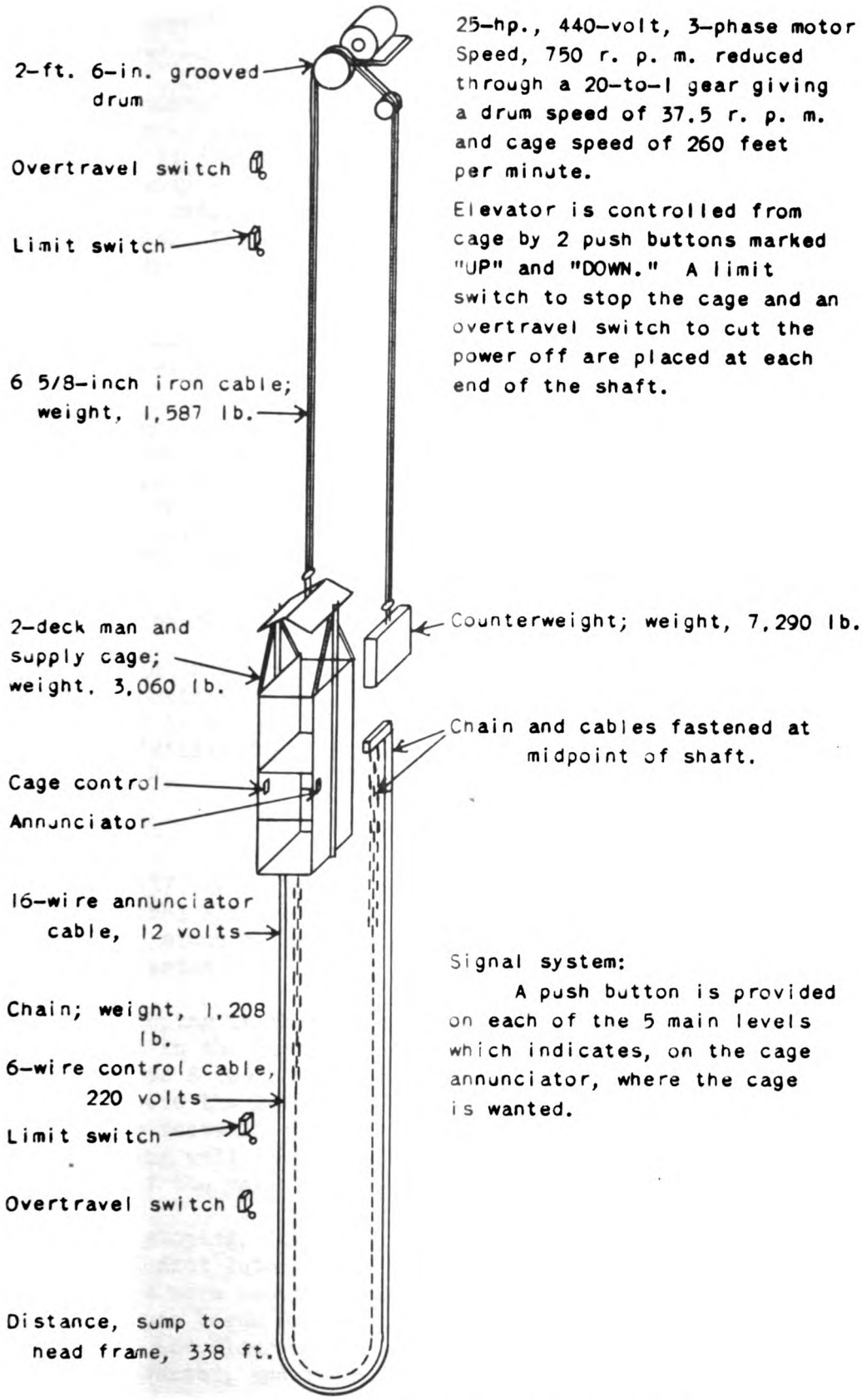
2-ft. 6-in. grooved drum
Overtravel switch
Limit switch
6 5/8-inch iron cable; weight, 1,587 lb.
2-deck man and supply cage; weight, 3,060 lb.
Cage control
Annunciator
16-wire annunciator cable, 12 volts
Chain; weight, 1,208 lb.
6-wire control cable, 220 volts
Limit switch
Overtravel switch
Distance, sump to head frame, 338 ft.
25-hp., 440-volt, 3-phase motor Speed, 750 r. p. m. reduced through a 20-to-1 gear giving a drum speed of 37.5 r. p. m. and cage speed of 260 feet per minute.
Elevator is controlled from cage by 2 push buttons marked "UP" and "DOWN." A limit switch to stop the cage and an overtravel switch to cut the power off are placed at each end of the shaft.
Counterweight; weight, 7,290 lb.
Chain and cables fastened at midpoint of shaft.
Signal system:
A push button is provided on each of the 5 main levels which indicates, on the cage annunciator, where the cage is wanted.

Figure 4.- Mine elevator 2. (Not to scale.)

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Underground Haulage.

The Extension tunnel, at an elevation of 11,515 feet, is the main entry to the mine workings. It is 7 by 8 feet in section and electrically lighted. The grade is 3/4 percent in favor of the loads. Ore is hauled out in trains of twenty 2-ton side-dump cars. Two 3 1/2 ton storage-battery locomotives are used in the tunnel. The track is of 30-pound rails; the gage is 24 inches. The daily production of 300 to 335 tons or ore is hauled out of the mine in two 8-hour shifts. A 3-ton storage-battery locomotive hauling ten 1-ton cars serves the 1,000-foot level.

On the upper levels of the mine 12-pound rails are used; the track gage is 18 inches. Mine cars of 18-cubic-foot capacity hold 1/2 ton of ore.

Access to the upper levels is by means of the Big raise, which extends from the Extension tunnel up to the 500-foot level, a vertical distance of 540 feet. The Big raise has a hoisting compartment and a manway compartment, each 4-1/2 by 4-1/2 feet. It is cribbed with 6- by 8-inch timber. A double-deck cage is used in the hoisting compartment and accommodates six men on each deck. The cage is operated by a double-drum electric-geared hoist using a 1-inch wire rope; the motor is 52 horsepower. A counterbalance runs in the manway compartment.

An innovation in this district is an underground elevator which is used in the upper workings of the mine instead of the conventional cage. A second elevator is to be installed between the 1,000-foot (Vienna) level and the 1,200-foot (Middle Tunnel) level. A sketch and description of it are given in figure 4.

Mining Methods.

In September 1937 ore on the 500-foot level was being mined by a cut-and-fill stoping method and ore on the 400-foot level by square-setting. Old stope fills were mined by an inclined underhand open-stoping method known locally as inverted rill stoping.

Cut-and-fill stoping is the usual mining method employed; in September 1937 it was used in the 523 stope on the 500-foot level. The stope width ranges from 3 to 8 feet; the average is 4-1/2 feet. The 500-foot level is 540 feet above the Extension tunnel, and level intervals range from 76 to 105 feet. The footwall of the vein is a thin layer of quartzite, then limestone; the hanging wall is yellow shale a few feet thick followed by porphyry. The dip of the vein is 70° to 80°.

Preparatory to stoping, inclined two-compartment cribbed chute raises were driven up at 25-foot intervals from a hanging-wall drift to intersect the vein. The raises were about 25 feet high; their tops were connected by a drift and stoping was begun by taking a 4-foot cut off the back of this drift, drilling from the floor with a stoper. Ore and waste were shot down together on lagging, sorted, and trammed out separately. A second 4-foot

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cut was drilled from lagging supported on temporary stulls. Timber sets were then erected and successive horizontal slices taken the full length of the stope, starting at one end. A miner drilled 10 to 15 holes per shift with a wet stoping drill, using 1-inch hollow quarter-octagon steel. The holes were loaded with two or three sticks of 45-percent-strength gelatin dynamite. The ore was broken down on 2- or 3-inch lagging; some sorting was done. After a horizontal slice had been mined the cribbed raises were carried ahead. A tugger hoist was used to pull the timbers up into the stope. Waste from footwall raises was then run in, and another slice started. Occasionally jackhammers were used for trimming.

The fill in old stopes was mined by inverted rill stoping. Cribbed raises 100 feet apart were first driven up through the fill; in some stopes the old raises could be used. Along the back of the old stope, from raise to raise, a horizontal row of stulls was put in and lagged. Under protection of the lagging, inclined slices of the fill were taken, starting at the top and mining downward toward a raise, so that the loosened material would run into the raise. Most of the work was done by picking; a little powder was used. Stulls were put in 4 or 5 feet apart to support working platforms. Occasionally a group of stulls was lagged off for storage of large pieces of waste. After the fill had been extracted the stope was left open.

Square-setting was being used in one stope on the 400 level. The method was applied to the mining of the fill from two old stopes, together with a pillar of mill-grade ore between stopes. The square-set stope had been begun at a place where the dips of the two veins flattened. It was advanced in a face seven sets wide (across the veins) and five sets high. The stope was advanced three sets at a time along the strike. The sets were then lagged off and filled with development waste from above. In September 1937 25 to 35 tons of ore was taken out of the stope in a shift; two shifts per day were worked.

Timbermen were paid $5.50 per day; machinemen and motormen, $5.25 per day; muckers, $4.40 per day.

Figures 5, 6, and 7 show details of ore-pass and raise construction at the London Mines & Milling Co.

Crushing Plant

The crushing plant, near the portal of the Extension tunnel at an elevation of about 11,500 feet, is operated two shifts per day. The flow sheet is shown in figure 8. Ore is hauled out of the mine in 20-car trains of side-dump cars, which are dumped on a horizontal grizzly of crossed railroad rails; the openings are 10 inches square. The oversize is broken by sledging and joins the undersize in one or the other of two storage bins. The first bin has a capacity of 150 tons and the second 125 tons. Home-made pulsator feeders driven by 3/4-horsepower motors feed the ore to a 16-inch horizontal belt conveyor 20 feet long. The belt travels at 60 feet per minute and delivers the ore to a 3- by 6-foot trommel with a 1-inch screen. The oversize, cleaned by water in the trommel, drops onto a 28-inch picking belt 32 feet lon

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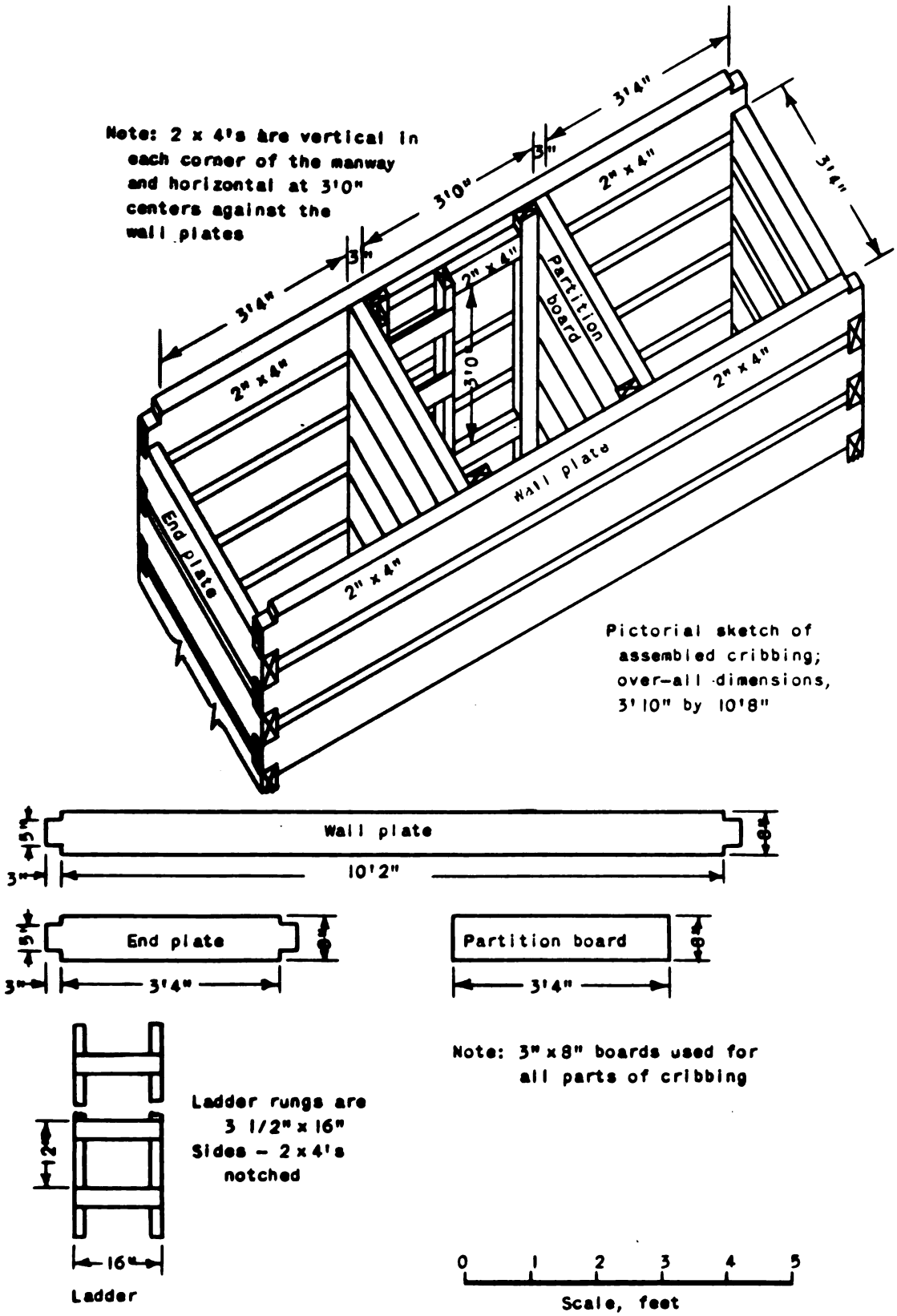

Figure 5.- Three-compartment raise cribbing.

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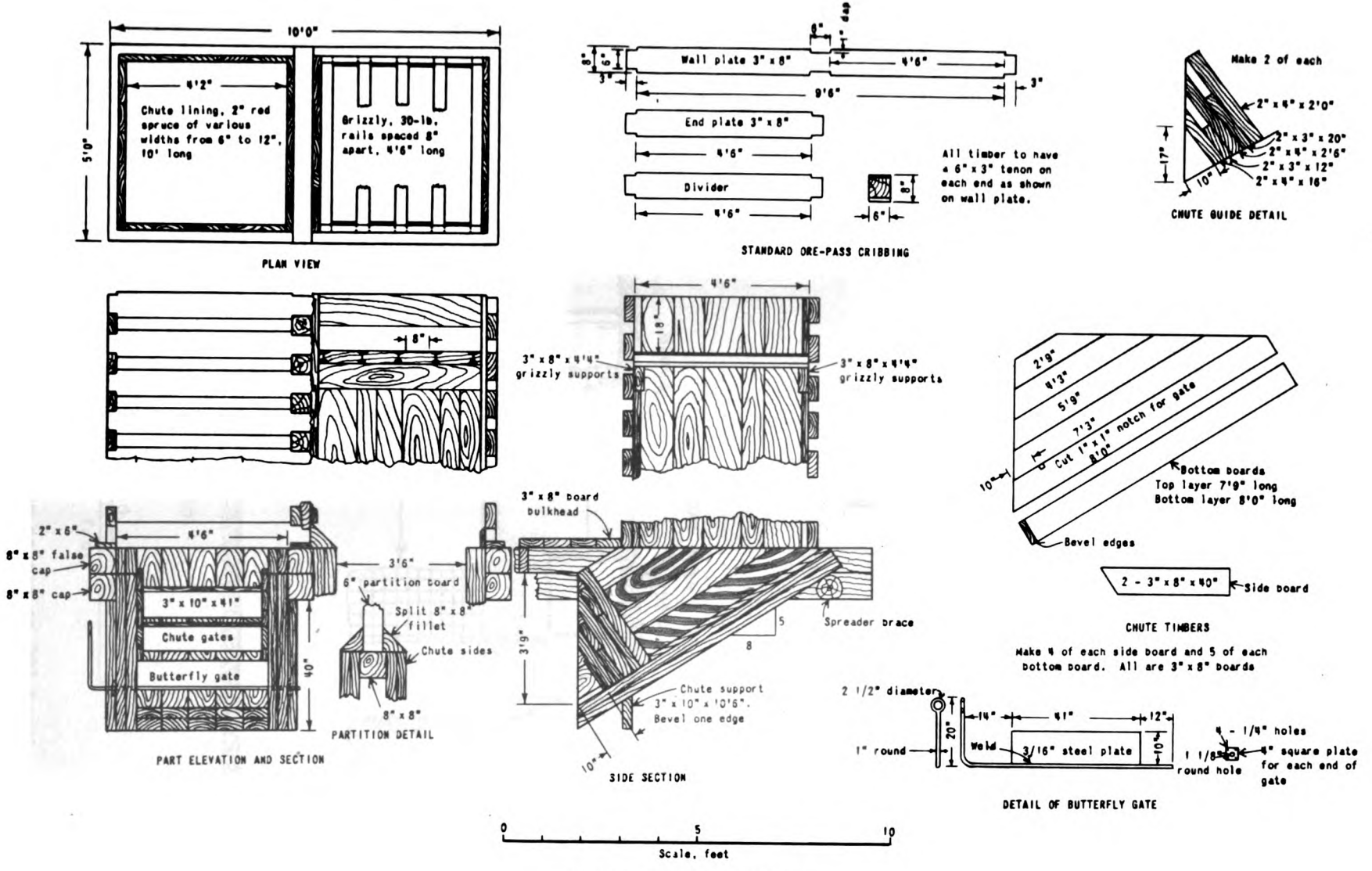

Figure 6.- Standard ore-pass details.

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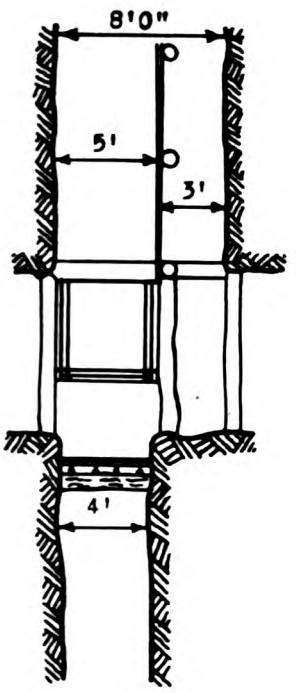
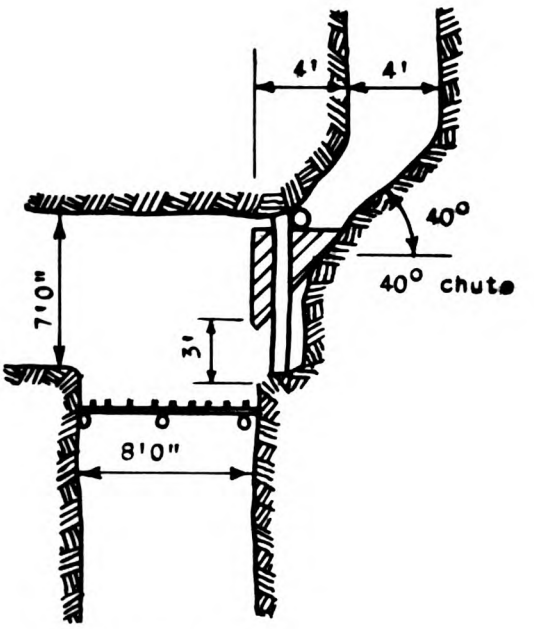


VIEW A – A



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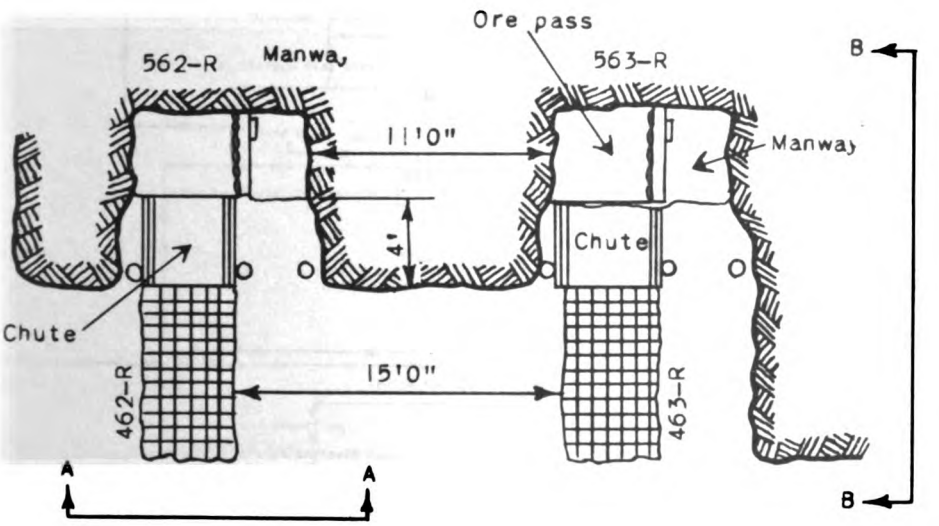

PLAN SECTION

0 5 10 20

Scale, feet

Figure 7.– Details of ore passes on 500 level.

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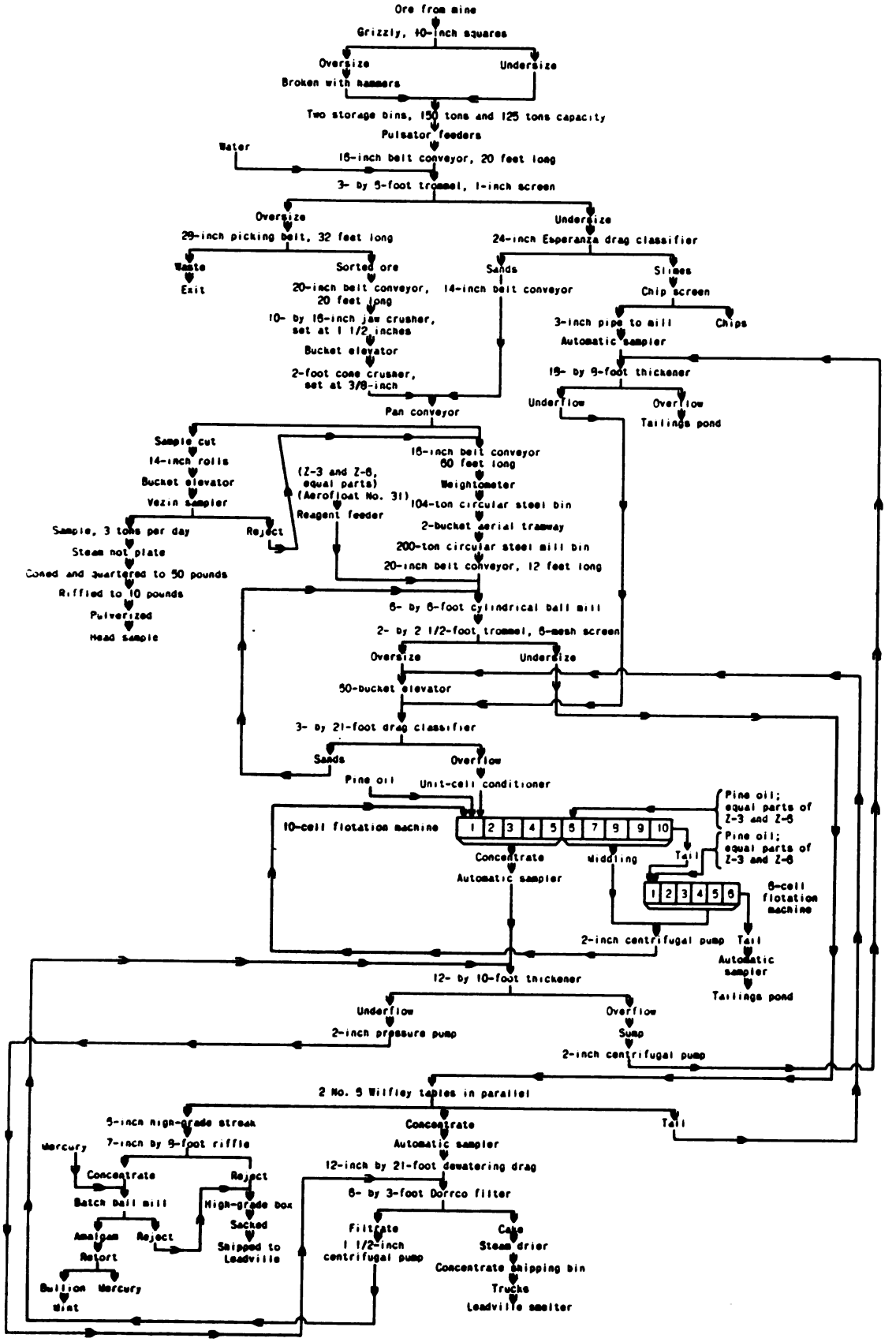

Figure 9.- Flow sheet of crushing plant and mill of the London Mines & Milling Co., 200 tons daily.

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The belt is horizontal; it is driven at a speed of 20 feet per minute by a 3-horsepower motor. Three men pick waste (porphyry) out of the ore and drop it into a bin. In September 1937 about 70 tons of waste was thrown out per day; usually about 25 percent of the ore is picked out. Tramp steel also is removed on the picking belt. The waste from the bin periodically is loaded into a 30-pound monorail bucket, which is pushed about 30 feet and then hooked on a 3/8-inch cable and pulled 150 feet up a 30° incline by a 7-1/2-horsepower hoist. The bucket is dumped into a bin on the waste dump, from which the ore train trams it over the end of the dump.

The sorted ore is delivered to a 20-inch belt conveyor, 20 feet long, which conveys it to a 10- by 16-inch Blake-type jaw crusher. The crusher is set at 1-1/2 inches; it is driven at 300 r.p.m. by a 15-horsepower motor using flat-belt drive. A bucket elevator raises the crushed ore about 25 feet to a 2-foot cone crusher set at 3/8-inch. The cone crusher is driven by a 25-horsepower motor, using V-belt drive. The product of the cone crusher drops onto a 16-inch belt conveyor 60 feet long. A small pan conveyor cuts a sample from the stream of ore between the cone crusher and the 16-inch belt. The sample cut is conveyed to a set of 14-inch rolls. The ground sample is then raised by a bucket elevator to a Vezin sampler, which takes a cut amounting to about 3 tons per 24 hours. The reject from the Vezin sampler is returned to the circuit on the 16-inch belt conveyor. The sample is dried on a steam hot plate, then coned and quartered to 50 pounds. It is riffled down to 8 or 10 pounds and pulverized for a final assay sample.

The undersize from the trommel goes into a 24-inch Esperanza drag classifier. A 14-inch belt conveyor delivers the sands to the 16-inch conveyor just described. The slimes pass over a chip screen and then through a 3-inch pipe that takes them from the crushing plant to an automatic sampler at the head of the mill building. The pipe is packed to prevent freezing in winter.

The 16-inch belt conveyor that receives the discharge from the cone crusher, the reject from the Vezin sampler, and the sands from the Esperanza classifier takes its load through a weightometer and discharges into a 104-ton circular steel bin. This bin is equipped with chutes for loading the buckets of a two-bucket gravity serial tramway that conveys the ore to a 200-ton circular steel bin at the head of the mill. The tramway is 750 feet long; buckets hold 1,100 pounds of ore. The vertical drop from the crushing plant to the mill is about 200 feet.

Mill

The mill is a 200-ton gravity-flotation plant of the side-hill type. In September 1937 it was operating at capacity; three shifts were working. The flow sheet is shown in figure 8. The ore is of medium hardness; the chief gangue mineral is quartz. Apparently no changes take place in the ore after it has been broken, even if it has stood for some time, as in old fills. The mill heads contain about 5 percent moisture.

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Ore from the 200-ton bin at the head of the mill is fed through an adjustable gate to a 20-inch belt conveyor 12 feet long that delivers it to the feed box of a 6- by 6-foot cylindrical ball mill. The ball mill is operated 24 hours daily in closed circuit with a 3- by 16-foot drag classifier. The circulating load ranges from 300 to 600 percent. The ball-mill discharge is 76 percent solids. Grinding is done with a load of 18,000 pounds of 4-inch cast-molychrome steel balls; the ball consumption is 3.25 pounds per ton of ore. Liners are of manganese steel; one set will grind about 45,000 tons of ore. The ball mill is driven at 25 r.p.m. by a 2,200 volt, 125-horsepower motor, using multiple V-belt drive.

The discharge end of the ball mill is equipped with a 2- by 2-1/2 foot trommel with a 6-mesh screen. The trommel oversize is raised about 40 feet by a bucket elevator carrying sixty 16- by 8- by 8-1/2 inch buckets. The elevator is driven at a speed of 360 feet per minute by a 15-horsepower motor. It delivers the trommel oversize and table tails to a 3- by 21-foot drag classifier, which makes 32 strokes per minute. The sands from the classifier are returned to the ball mill; the overflow, containing 25 percent solids, goes to flotation.

The slimes from the crushing plant, amounting to 10 tons of solids per 24 hours, are delivered by the 3-inch pipe previously mentioned to an automatic sampler and then to an 18- by 8-foot thickener. The overflow from the thickener is conveyed by a launder to the tailings pond; the underflow is delivered to the drag classifier just described.

Flotation reagents first enter the flow sheet at the feed box of the ball mill, into which a reagent feeder of the revolving-bucket type feeds 0.06 pound of a half- and half mixture of Z-3 and Z-6, and 0.2 pound of Aerofloat No. 31, per ton of ore. The classifier overflow is conditioned in a unit cell and then enters the first cell of a 10-cell flotation machine. The impeller in the first cell is driven by a 5-horsepower motor and those in the other cells by individual 3-1/2 horsepower motors. Air for aeration of the pulp is supplied at a pressure of 2 pounds per square inch by a Root-type blower running at 525 r.p.m. This type of flotation machine was selected on account of its flexibility. From 2 to 4 cc. of pine oil per minute is added in the first cell, and 2 cc. of pine oil per minute and 0.04 pound of a half-and-half mixture of Z-3 and Z-6 per ton of ore are added in the sixth cell. The number of cells producing a concentrate is adjustable, ranging from 1 to 6. Usually a concentrate is produced in the first five cells which contains about 75 percent of the total values recovered. The concentrate passes through an automatic sampler and then into a 12- by 10-foot thickener. The thickener underflow is delivered by a 2-inch pressure pump to a 6- by 3-foot Dorrco filter. The drum makes one revolution in 4 minutes. The thickener overflow collects in a sump, from which a 2-inch centrifugal pump delivers it to the 18- by 8-foot thickener at the head of the mill.

The remaining cells of the 10-cell machine make a middling. The tails pass to the first cell of a 6-cell machine of the same type as the 10-cell machine. From 1 to 2 cc. of pine oil per minute and 0.03 pound of the

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mixed xanthates per ton of ore are added in the first cell. All six cells make a middling, which (with the middling from the 10-cell machine) is pumped by a 2-inch centrifugal pump back to the first cell of the larger machine. The tails from the smaller machine are sampled automatically and then conveyed to the tailings pond in an open V-type launder having a 3-percent grade.

The undersize from the ball-mill trommel is split between two Wilfley tables that make a high-grade streak, a concentrate, and a tail. The tables make 274 strokes per minute; the stroke is 3/4 inch. Each table treats about 200 tons per day. The high-grade streak, about 6 inches wide, is put over a riffle 7 inches wide by 8 feet long. The riffle is cleaned out every day. The riffle concentrate is amalgamated in a small batch ball mill every 2 days. The resulting amalgam is retorted twice a month and the bullion taken to the Denver Mint. The rejects from the riffle and the batch ball mill are sacked and shipped to the American Smelting & Refining Co. at Leadville.

The main purpose of the tables is to remove coarse sulfides as early as possible; this eliminates further grinding and relieves flotation. The concentrates from the tables pass through an automatic sampler and are then dewatered in a 12-inch by 21-foot drag. They are filtered with the flotation concentrates on the 6- by 3-foot Dorrco filter. About equal tonnages of table and flotation concentrates are made. The table concentrates, being coarser than the flotation concentrates, settle against the filter cloth, thus facilitating filtering of the fines and tending to prevent blinding of the filter. The filter cake is steam-dried and dumped into a shipping bin, from which it is loaded into 7-ton trucks. It is hauled by a trucking company to the American Smelting & Refining Co. at Leadville. Table tails are re-treated; they are returned to the 60-bucket elevator that feeds the drag classifier.

The flotation tails flow by launder about 300 feet to the upper of two tailings ponds. Most of the coarse material settles in the upper pond; the overflow passes to a lower and larger pond. The relatively clear overflow from the second pond flows into South Mosquito Creek, which empties into the Platte River about 6 miles below the London mine. The mill discharges 180 to 190 tons of tailings per day.

The filtrate from the Dorrco filter is pumped by a 1-1/2-inch centrifugal pump up to the 14- by 8-foot flotation-concentrate thickener.

Automatic samplers used in the crushing plant and mill are of the electric-hydraulic type. The pulp stream is cut twice every 10 minutes.

Screen analyses of mill products are shown in table 3.

Ample water of good quality for milling is obtained from the mine; no water is reclaimed. The mill uses 2.85 tons of water per ton of ore or about 0.4 ton of water per minute.

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TABLE 3. - Screen sizes of mill products, London Mines & Milling Co., January to June 1938

Screen	Grinding	Classifiers			Tables	Flotation		
	Primary feed	Feed	Discharge	Overflow	Heads	Heads	Concentrates	Tails
Minus 1 inch square plus 1/2 inch square..	28.20	-	-	-	-	-	-	-
Minus 1/2 inch square plus 1/4 inch square	34.92	-	-	-	-	-	-	-
Minus 3- plus 4-mesh.....	11.85	-	-	-	-	-	-	-
Minus 4- plus 10-mesh	8.72	-	-	-	-	-	-	-
Minus 10- plus 14-mesh	3.08	-	-	-	-	-	-	-
Minus 14- plus 20-mesh	1.66	-	-	-	-	-	-	-
Minus 20- plus 48-mesh	1.36	-	-	-	-	-	-	-
Minus 48- plus 65-mesh	3.92	72.58	85.23	14.27	58.93	14.27	21.80	11.45
Minus 65- plus 100-mesh	1.72	7.72	5.76	15.19	9.03	15.19	11.54	16.63
Minus 100- plus 150-mesh	1.01	3.61	2.16	8.98	4.71	8.98	10.65	13.50
Minus 150- plus 200-mesh	1.13	2.99	1.52	9.78	3.74	9.78	11.29	9.27
Minus 200-mesh	2.43	13.10	5.33	51.78	23.59	51.78	44.72	49.15
	100.00	-	-	-	-	-	-	-

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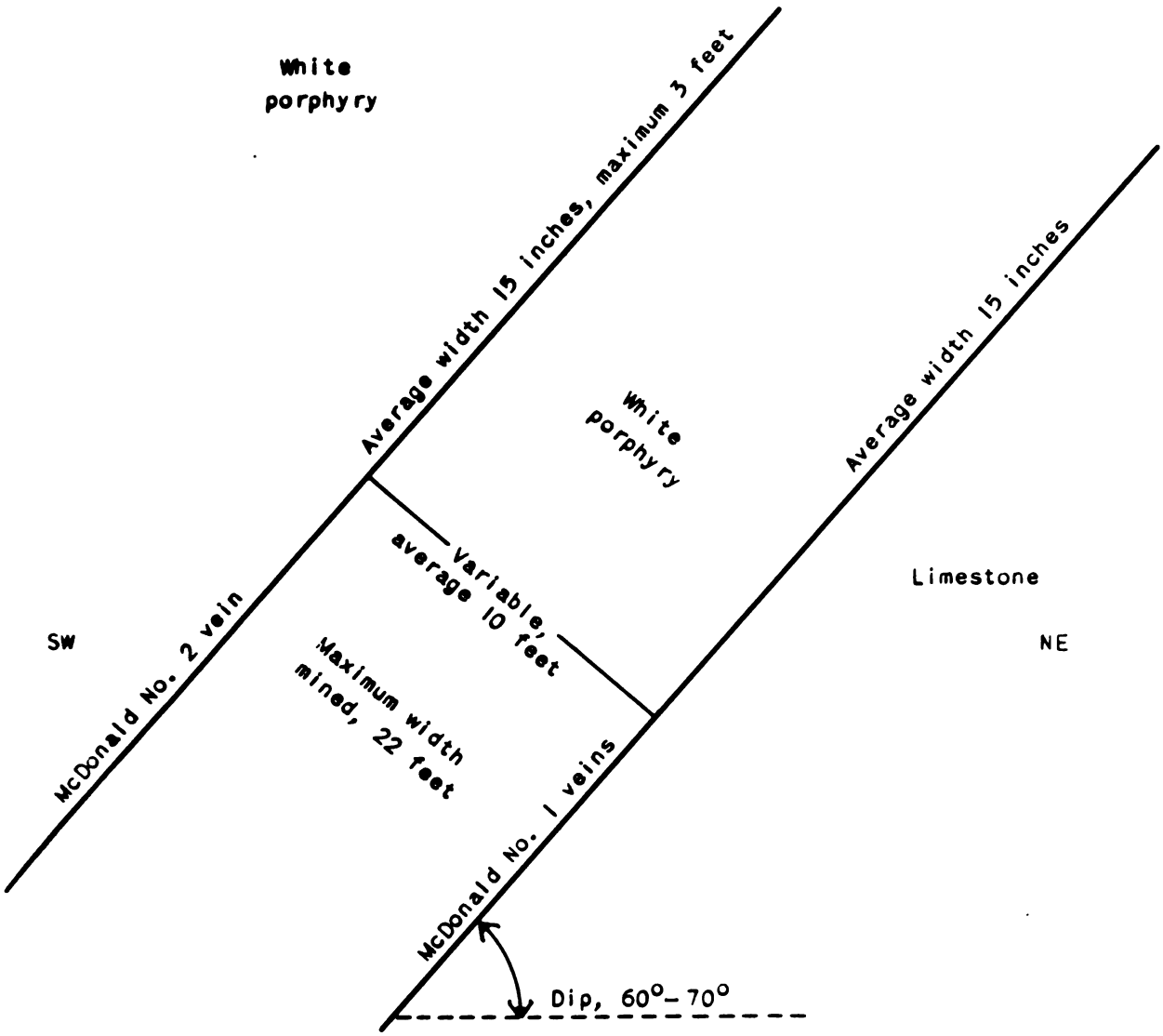

Figure 9.– Vertical cross section showing geologic relations of McDonald No. 1 and McDonald No. 2 veins in the London–Butte mine.

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Electric power is bought from the Public Service Co. of Colorado; it is stepped down at the mine from 13,000 volts. All motors in the mill are 440-volt except the ball-mill motor, which is 2,200-volt. Nearly all the motors are equipped with multiple V-belt drives.

Table 4 presents metallurgical data for the first 6 months of 1938.

TABLE 4. - Metallurgical data

Plant: The London Mines & Milling Co.
Period covered: January through June 1938.

Total tons ore treated.....tons (dry)	37,900
Days operated	181
Hours operated per day.....	24
Operating time .....percent	97.6
Average tonnage per 24 hours.....tons (dry)	209.5
Concentration ratio	16 into 1
Net water consumption .....gallons per ton ore	735
Ball consumption .....pounds per ton ore	3.25
Liner consumption ..... do.....	0.39

Ten men are employed in the mill - 1 superintendent, 1 metallurgist, 1 repair man, 3 operators, 3 helpers, and 1 relief operator, who substitutes for each regular operator and helper 1 day per week.

Costs were not available for publication.

The London-Butte Gold Mines Co.

The property of the London-Butte Gold Mines Co. is 5-3/4 miles from Alma, just across South Mosquito Creek from the London Mines & Milling Co. Acknowledgment is made to George F. Schreiber, general manager, and to the members of his staff who kindly contributed the information on company mining and milling operations.

Mine

Local Geology.

Most of the rocks in the mine are white and gray porphyries and limestone. Veins occupy fault fissures and contact zones between the white porphyry and the limestone. Most of the ore mined has come from the McDonald No. 1 and the McDonald No. 2 veins and the region between them. The relationship of the veins and the enclosing rocks is shown in figure 9. Nearly all the production has been from an ore shoot that includes both veins and pitches about S. 20° E. The shoot has been mined from the second level to the fourth for a total inclined length of about 1,500 feet. In September 1937 the management was searching dilligently for a continuation of the shoot on the fifth level.

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Mine Plant.

Hoisting at the main shaft is done by a 10- by 14-inch second-motion single-drum steam hoist, rated at 100 horsepower. The head frame is of timber, is 51 feet high, and is surmounted by a 5-1/2-foot sheave. A 3/4-inch wire hoisting rope is used.

The main shaft is vertical. It is two-compartment to the fourth level and three-compartment from the fourth to the fifth (bottom) level. The hoisting compartment is 54 by 56 inches, the manway a little narrower. A single-deck cage is used in the hoisting compartment. It accommodates one 13-cubic-foot car or six men.

A powder magazine is in a crosscut on the tunnel level. The cager keeps two or three additional boxes on each station. At shooting time he takes down the necessary primers from the shaft house, where they are made.

Compressed air for drilling is supplied at 95 pounds per square inch by a two-stage compressor, rated at 535 cubic feet per minute. It is driven at 225 r.p.m. by a 75-horsepower motor, using a short flat-belt drive. A 4-inch main air line extends down the shaft from a 3-1/2- by 10-foot receiver outside the shaft house. Two-inch lines extend into the levels, from which 1-inch lines lead to the working places.

Water for drilling is taken from the discharge line of the pump on the second level. A water line extends throughout the mine. Working places are served by 1/2-inch lines.

Prospecting.

In September 1937 prospecting was limited to the driving of drifts, crosscuts, and raises on the fifth level of the mine in an attempt to find the main ore body. Occasional prospecting has been done from stopes. Crosscuts have been driven to prospect fissures that have produced ore at other properties. The London vein has been cut in eight places on various levels; it has been consistently barren.

Exploration work has proceeded downward along McDonald No. 1 and McDonald No. 2 veins.

Drifts and crosscuts are driven 5 by 7 feet in section. Some crosscuts have stood untimbered, but all drifts require timber. Formerly 8- by 8-inch sets at 5-foot centers were employed. In September 1937 round timbers were being used; sets were lagged on the top and sides. Drill rounds are not standardized; 10 to 22 holes are used - the latter number on the fifth level. Rounds usually break 4-1/2 feet. Drilling is done on company time with a drifting machine mounted on a vertical column, using 1-1/8-inch round steel. Detachable bits are employed; those for crosscuts and drifts in waste have a center waterhole and those for drifts in ore a side waterhole. They are reground at the mine. Starting bits are 2-1/4-inches and

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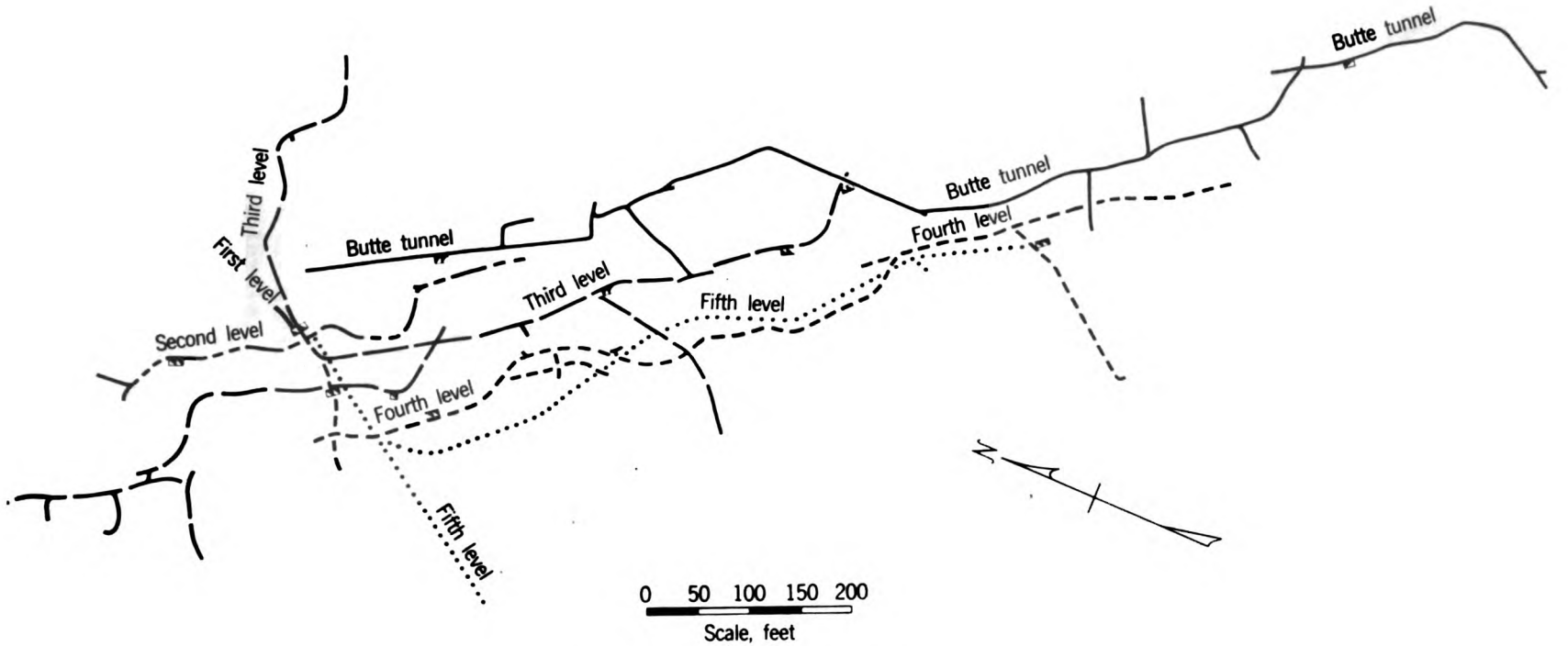

Figure 10.–Underground workings, London Butte mine.

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finishers 1-5/8 inches in diameter. A small board with a handle on one side serves as a rack for transporting bits; 25 to 30 bits are mounted thereon. Gelatin dynamite of 40-percent strength is used; it is fired by fuse and no. 8 blasting caps.

Machinemen and timbermen receive $5.25 to $5.50 per day; shovelers and trammers, $4.65 per day.

Mining Method.

The London-Butte shaft was sunk in a block of ground between the London fault, dipping east, and the West London fault, dipping west.

The first level of the mine is an adit level at the elevation of the shaft collar; it is called the tunnel level. The second level is 130 feet below the shaft collar. Succeeding level intervals are 120, 125, and 136 feet, respectively, making the fifth level 511 feet below the shaft collar. Figure 10 shows the underground workings.

Ore broken on the tunnel level is dumped down an ore pass to the second level. It is then hand-trammed to the shaft in 1-ton cars and hoisted to the mill. In September 1937 most of the ore was being mined on and just above the third level. It was trammed to the shaft on the third level and hoisted to the mill.

Most of the ore is mined by square-set stoping, a method adopted for flexibility. Stull sets are used to support the walls of the stopes. The average width of the stope is 10 feet; the maximum width is about 22 feet. The width mined includes McDonald No. 1 and McDonald No. 2 veins (see fig. 9) and the ground between them. The ground between the veins assays about 0.12 ounce of gold per ton.

Open stopes were used on the tunnel level.

Stoping drills are 7/8-inch quarter-octagon steel; jackhammers, 7/8-inch hexagon steel. The same bits are used with both types of steel.

In September 1937, 85 percent of the ore production was from stopes on the third level, 10 percent from the fourth level, and 5 percent from the tunnel level.

In July 1938 the company was mining ore in the south end of the mine between the 400- and 500-foot levels. The vein was only 2 feet wide. From the 45 sublevel nearly vertical raises were driven up in the ore to the top of the ore body. The raises were about 25 feet apart and were timbered with sets 7 feet high. The width of the sets was limited to the width of the vein. Posts of the first set were vertical; posts of succeeding sets paralleled the dip of the vein. Caps were 5 feet apart and extended from wall to wall. When a raise had been completed the ore on one side of it was broken down in a series of vertical slices one set wide, starting at the sublevel.

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Slabbing rounds of 6 to 8 flat holes 5 to 6 feet deep were drilled from platforms in the raise; 1 to 3 sticks of 45-percent-strength gelatin dynamite were loaded in each hole. A round broke down about 7 tons of ore. Timber sets similar to those in the raise were carried upward as each slice advanced.

On the main levels 12-pound rails are used; the gage is 18 inches. On the tunnel level and in some of the stopes and sublevels 8-pound rails are used. Mine cars hold 13 cubic feet; they are end-dump, handled by one man.

Chutes are not standardized; most of them have board gates and a steel apron operated by a lever, as in the London mine.

All shoveling and tramming are done by hand; no scrapers are used in the mine.

Labor.

In September 1937 the mine worked two shifts a day for 13 days in 2 weeks; the mill worked three shifts a day 7 days a week.

A boarding house at the mine accommodated 35 single men. Three family men occupied cabins at the mine. The remaining laborers came to work from Alma and Fairplay.

During the summer of 1937 about 75 men were employed at the London-Butte property, distributed as shown below:

Average daily labor, summer of 1937

	Number	
Surface:		
Hoistmen	3	
Blacksmith shop	3	
Laborers	6	
Office man	1	
Assayer	1	14
Mine:		
Shift bosses	3	
Miners	15	
Muckers	20	
Trammers	10	
Timbermen	2	50
Mill:		
Mill operators	6	
Crusher men	2	
Tailings men	3	11
Total men per day		75

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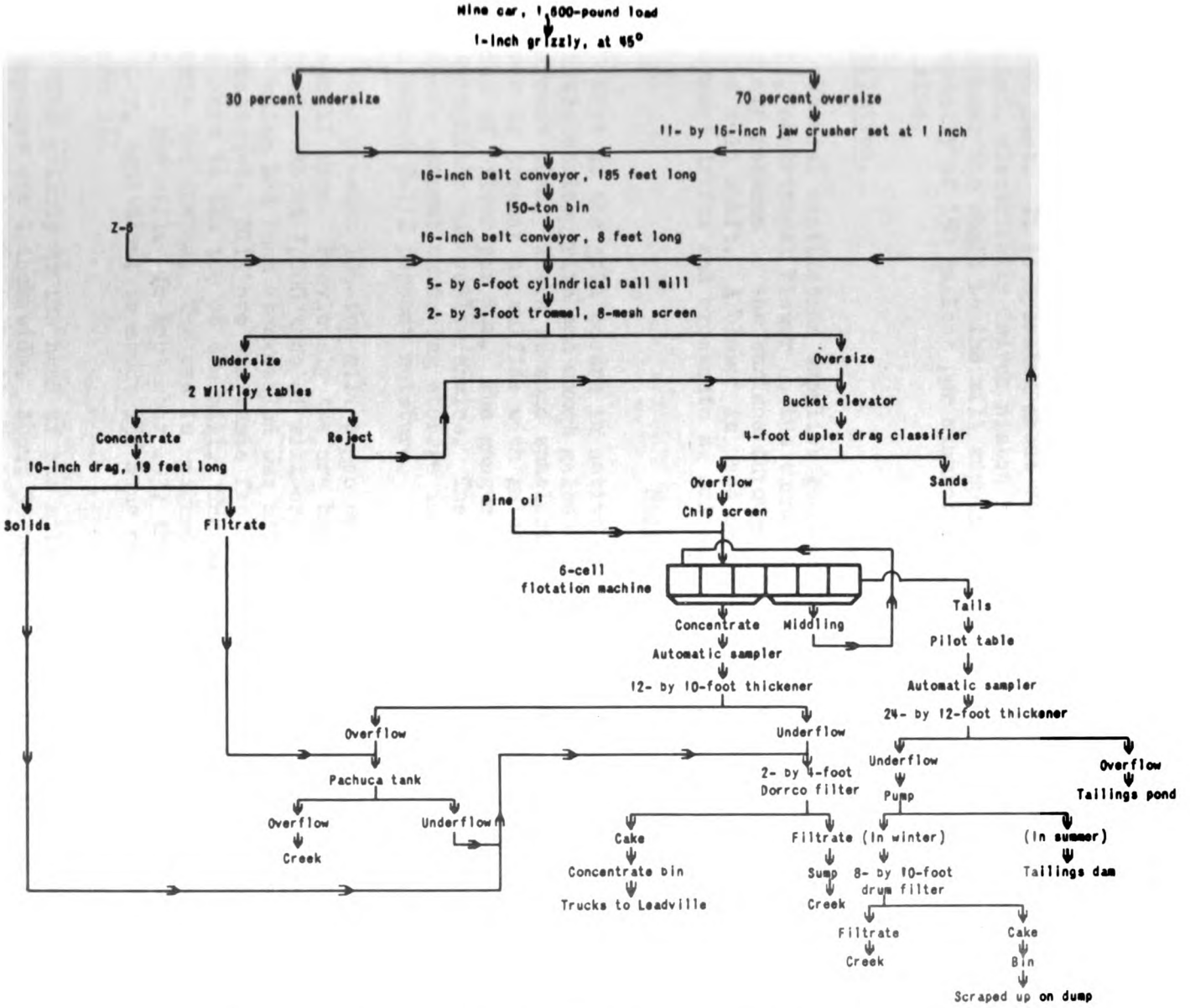

Figure 11.- Flow sheet of London-Butte mill, 100 tons daily.

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Water Supply and Mine Drainage.

Drinking water for the camp is obtained from a spring on Pennsylvania Mountain. Water for other camp uses is obtained from a 1,500-gallon tank on the surface, supplied by a 5- by 5-inch piston pump on the second level of the mine. The pump is controlled by the hoistmen. A two-stage, float-controlled, electrically driven centrifugal pump on the fifth level pumps from the shaft bottom just below that level to a small sump on the fourth level. The capacity of the pump is 75 gallons per minute against a head of 350 feet. It is operated about five-eighths of the time. A float-controlled, electrically driven piston pump on the fourth level pumps from a sump near the shaft to the mill supply tank on the surface. The pump has a capacity of 150 gallons per minute; it operates about three-fourths of the time.

Ventilation.

Natural ventilation supplies good air to most of the workings. A small, centrifugal blower on the tunnel level blows air into the main stope. This air returns to the surface through a raise to the second level and then up the main shaft. A blower is used on the fifth level for ventilating development drifts and crosscuts as driven.

Mill

Most of the gold occurs in native form with pyrite. The ore contains a little chalcopyrite and enough galena to make the concentrates assay 5 or 6 percent lead. There is some sphalerite, but not enough to be penalized. Silver is present as sulfide with galena; the concentrates contain about 2 ounces of silver per ton. The gangue comprises light and dark porphyries and graphitic and yellow shales. The ore crushes easily. It undergoes no apparent alteration during storage in shrinkage stopes. The mill heads contain about 2-1/2 percent moisture.

The present 100-ton mill began operation March 7, 1936; it is of the side-hill type. Previously the ore had been sorted and the high-grade shipped. About 7,000 tons of mill-ore grade (average, 0.32 ounce gold per ton) which had been stock-piled was milled during 1936. Sorting has been discontinued. Mill ore and waste from the mine are hoisted in 13-cubic-foot cars to the top of the mill. The waste is trammed 70 feet over a trestle and dumped. The ore is weighed and then dumped on a grizzly at the head of the mill. In September 1937 the mill was treating 110 tons of ore per day, equivalent to about 137 mine cars. The flow sheet is shown in figure 11.

The grizzly at the head of the mill is 7 feet long and set at 45°; the spaces are 1 inch wide. About 30 percent of the ore passes through. The oversize is fed to an 11- by 18-inch jaw crusher set at 1 inch. Tramp steel is picked out by the crusher man. The crusher is driven at 250 r.p.m. by a 25-horsepower motor with multiple V-belt drive. A 16-inch belt con-

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veyor driven by a 7-1/2-horsepower motor carries the crushed ore and the grizzly undersize up a 14° slope 185 feet long. The ore is discharged into a 150-ton bin, from the bottom of which it is fed through a regulated gate opening to another 16-inch belt conveyor. This conveyor is 8 feet long; it delivers the ore to the feed box of a 5- by 6-foot cylindrical ball mill. About 150 cc. per minute of a 5-percent solution of Z-6 is added to the ball mill feed by a siphon-type reagent feeder. The ball mill is in closed circuit with a drag classifier; the circulating load is 200 percent. The mill is driven at 24 r.p.m. by a 75-horsepower motor and is run 24 hours a day. Manganese-steel liners for the shell last about 5 months; intake liners and grate liners last 8 months. Grinding is done with a load of 3-1/2 tons of 4-inch drop-forged manganese-steel balls. Ball consumption is 1-1/2 pounds per ton of ore. A 2- by 3-foot trommel with an 8-mesh screen is used on the discharge end of the ball mill.

The trommel undersize is divided equally between the two No. 6 Wilfley tables. These tables make 150 half-inch strokes per minute. The table concentrate contains about 60 percent of the total sulfides recovered. They are dewatered in a 10-inch drag 19 feet long, which delivers them to a 2- by 4-foot Dorrco filter. The filtrate from the drag runs into a Pachuca tank used as a settler. The table reject joins the oversize from the ball-mill trommel in the boot of a bucket elevator. The elevator has twenty 7- by 14-inch buckets and is run at 200 feet per minute. It raises the pulp about 12 feet to a 4-foot duplex multizone drag classifier. The sands from the classifier are returned to the ball mill. The classifier overflow contains 30 percent solids; screen analyses show 5 percent plus 65-mesh and 70 percent minus 200-mesh. It flows over a chip screen and then into the second cell of a six-cell flotation machine.

Pine oil amounting to 40 cc. per minute is fed into the launder that conveys the classifier overflow to the flotation machine. The first three cells of the machine make a concentrate; the last three make a middling that is returned to the first cell. The concentrate flows through an automatic sampler and into a 12- by 10-foot thickener. A diaphragm pump raises the thickener underflow to the same 2- by 4-foot Dorrco filter to which the table concentrates were delivered. The thickener overflows into the Pachuca tank that receives the filtrate from the 10-inch by 19-foot drag. The Pachuca tank overflows into the creek; the solids are filtered with the table and flotation concentrates. The filter cake contains 8 percent moisture. It drops into a concentrate bin from which it is loaded through arc gates into trucks and hauled to the American Smelting & Refining Co. at Leadville. Although the mill is only about 14 miles from Leadville by way of the old stage route over Mosquito Pass the trucking company prefers the 90-mile haul over main highways (see p. 16). The trucking rate to Leadville is $4.50 per ton. The filtrate from the Dorrco filter flows to the mill sump, which overflows into the creek.

The flotation tailings are treated on a pilot table to check the performance of the flotation machine. They then pass through an automatic sampler and into a 24- by 12-foot thickener. A launder conveys the thickener

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overflow to the tailings pond. The underflow is treated differently in summer than in winter. In summer it is pumped to the tailings pond, where it is used to build up the dam. In winter it is pumped to an 8- by 10-foot drum filter. The filtrate flows into the creek and the filter cake drops into a bin from which a scraper removes it and stacks it on the waste dump.

A 12- by 6-inch vacuum pump serves both the Dorrco and the drumtype filter. Compressed air for the filters and for the flotation machine is supplied at a pressure of 1-1/2 pounds per square inch by a Root-type blower. A small centrifugal pump delivers the filtrates from both filters to the sump.

All motors in the mill are 440-volt. The blower and diaphragm pumps are driven by flat rubber belts, other equipment by multiple V-belts.

Drinking water is piped from a spring on Pennsylvania Mountain. Water for milling is pumped from the mine into a 20- by 14-foot cement tank on the surface above the mill. The cement tank overflows into a 14- by 14-foot mill-storage tank. The mill uses about 3 tons of water per ton of ore. No water is reclaimed.

Table concentration relieves the flotation machine and decreases the amount of grinding necessary. The table concentrates assay about twice as high in gold as the flotation concentrates, the respective assays being about 4 and 2 ounces of gold per ton. The insoluble in the table concentrates is only about 4 percent, whereas in the flotation concentrates the insoluble is about 15 percent. This gives the table concentrates an added advantage over the flotation concentrates, inasmuch as the smelter pays for the excess of iron over insoluble.

The pilot table, in acting as a check on flotation, sometimes shows a streak of pyrite that has been filmed by graphitic shale. The addition of fuel oil and soda ash to float the pyrite is thus indicated.

Sampling.

A head sample is taken by hand every half hour from the feeder belt to the ball mill. The full stream of ore is taken by means of a scoop. Samples from each shift are kept in a separate box.

The classifier overflow is hand-sampled every half hour; the density is determined every hour. The filtrate from the 10-inch drag used to dewater the table concentrates is also hand-sampled every half hour. After passing over the pilot table the flotation tails are sampled automatically every 15 minutes. The concentrate cake from the filter is hand-sampled every half hour. The sample usually agrees fairly well with the sample taken at the smelter, which is made up of every fifth shovelful from the truck.

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TABLE 5. - Metallurgical data

Plant: London-Butte Gold Mines Co.
Period covered: Mar. 7 to Dec. 31, 1936.

Ore treated	dry tons	31,206.68
Concentrates produced	do.	3,939.25
Average heads	ounces gold per ton	.331
Average concentrates	do.	2.492
Average tailings	do.	.026
Gold recovered	ounces	9,762.41
Silver recovered	do.	6,726.91
Lead recovered	pounds	423,375.00
Gold recovery	percent	92.79
Ratio of concentration		7.975
Operating time	percent	92.9

Mill Labor.

In September 1937 the mill employed a crew of eight men, as shown below:

Daily mill labor

Number per shift	Operation	Shifts	Rate	Daily cost
1	Operator	3	$ 5.75	$ 17.25
1	Helper	3	4.65	13.95
1	Crusher man	2	4.65	9.30
-	Total	8	-	$ 40.50

In addition to the above, three men were employed on the day shift building the tailings dam.

Smelter Payments.

The smelter pays for the metals in the concentrates on the following basis:

Gold:

Average price	per ounce	$34.9125
Mint price	do.	20.6700
Premium	do.	$14.2425
90 percent	do.	12.81825
Pay	do.	32.81825

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Silver:
Pay for 95 percent at daily New York quotation.

Lead:
Deduct 1.5 from assay; pay for 90 percent of balance at daily New York quotation less 1.5 cents per pound.

Zinc:
Penalty for over 8 percent.

Moisture:
Penalty for over 10 percent at 5 cents per unit.

TABLE 6. - Smelter settlement sheet

Metal quotations of March 25, 1937: Silver, $0.77 per ounce
Lead, $0.06958 per pound

	Gold	Silver	Lead	Insoluble	Iron	Zinc
American Smelting & Refining Co.	2.38	1.4	5.8	8.2	35.0	4.9
Mine	2.45	1.6	6.4	8.0	35.3	-
Metallics	.024	-	-	-	-	-
Umpire	2.45	-	-	-	-	-
Settlement	2.474	1.5	6.1	8.1	35.15	4.9

Wet weight: 106,360 pounds. Frozen weight: 106,520 pounds
Moisture: 10 percent. Dry weight: 95,724 pounds.

Payments per ton	
Gold: 2.474 ounces at $32.81825	$ 81.19
Silver: 95 percent of 1.5 ounces at $0.77	1.10
Lead: 90 percent of 4.6 units at 5.458 cents	4.53
	$ 86.82
Total deductions	5.91
	$ 80.91

95,724 pounds at $80.91 per ton		$ 3,872.51
Haulage at $4.50 per ton	$ 239.67	
Switching: Trucks to railroad cars to bin	5.40	245.07
Net proceeds		$ 3,627.44

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Trucking

Concentrates and supplies are hauled by a trucking company in Alma. The rate for hauling between the London-Butte mine and Leadville is $4.50 per ton; this applies to concentrates from the mine and to supplies for the mine. The rate for 1936 was $4.75 per ton. The rate on supplies from Denver is $0.51 per hundred pounds.

Costs

The following prices represent the cost of the various items of timbering at the mine:

Sawed lumber, per M feet b.m.	$ 23.00
Round timber, each pole	0.45 to 1.25
16-foot lagging, half-round, each	.45
5-foot lagging, each	.15
5-foot slabs, each	.08
Stulls (average 6 feet long), per linear foot	.06

Coal is purchased from Crested Butte, Colo.; the cost is shown below:

Cost of coal at mine, Crested Butte, Colo. per ton	3.25
Railroad freight to Buena Vista, Colo.,do.	2.41
Trucking from Buena Vista to London-Butte mine,,do.	2.75
Total delivered price of coal,,do.	$8.41

Labor costs for the mine and mill for July 1937 are shown in table 7. Table 8 shows the distribution of equipment and supplies and table 9 the distribution of power. Costs are summarized in table 10. The distributions shown are typical of recent operations. There were 28 working days during the month; 2,359.34 dry tons were milled.

During 1936, a total of 31,206.68 tons was mined and milled. Unit costs for that year were:

	Per ton
Direct mining	$ 4.19
Direct milling	1.86
Total direct mining and milling	$ 6.05
Denver office, taxes, insurance	.76
TOTAL	$ 7.81

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TABLE 7. - Distribution of labor cost, London Butte-Gold Mines Co., July 1937

Item	Monthly cost	Cost per ton
Mine:		
Foreman and assistant foreman	$ 450.00	$ 0.191
Mining	3,534.78	1.498
Timbering	2,043.95	.866
Tramming	484.50	.206
Drift maintenance	156.05	.066
Hoisting	511.50	.217
Top work	290.04	.123
Sawmill	252.33	.107
Shop work	444.55	.189
Assaying mine samples	60.00	.025
Development (fifth level)	493.57	.209
Construction (new wall on boiler)	448.41	.190
Yard work (cleaning)	59.38	.025
Drill-bit grinding	48.23	.020
Repairs to buildings:		
Leveling bunkhouse	39.24	.017
Leveling waste trestle	7.67	.003
Mine payroll	9,324.20	$ 3.952
Accident compensation	617.28	.261
Old-age annuity	188.48	.080
Unemployment insurance	94.24	.040
TOTAL MINE LABOR	$ 10,224.20	$ 4.333
Mill:		
Foreman	250.00	0.106
Operating	686.40	.292
Crushing	205.76	.087
Tailings disposal:		
Care of dam	234.24	.099
Construction of launder	74.77	.032
Shop work	208.51	.088
Assaying-mill samples	90.00	.038
Crushing and drying mill samples	56.38	.024
Yard work (cleaning)	36.00	.015
Mill pay roll	$ 1,842.06	$ 0.781
Accident compensation	30.10	.013
Old-age annuity	38.84	.016
Unemployment insurance	19.42	.008
TOTAL MILL LABOR	$ 1,930.42	$ 0.818
General pay roll:		
Administration, superintendence	$ 1,000.00	$ 0.424
TOTAL LABOR FOR JULY 1937	$ 13,154.62	$ 5.575

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TABLE 8. - Distribution of equipment and supplies cost,

London-Butte Gold Mines Co., July 1937

Item		Monthly cost	Cost per ton
Mine:			
Stoping drill, first charge on 5-month basis		$ 80.00	$ 0.034
Bit grinder, third charge on 12-month basis		62.50	.027
Materials of construction, new wall for boiler		49.98	.021
Timber		966.81	.410
Weighing 21 loads of supplies at 20 cents		4.20	.002
Dynamite, 3,420 pounds at $11 per cwt		376.20	.160
Carbide, 1,100 pounds at $5.85 per cwt		64.35	.027
Fuse, 3-1/2 cases at $36		126.00	.053
Caps, 1,950 at $18.5517 per thousand		36.17	.015
Cylinder oil, 43 gallons at $0.511		21.97	.009
Compressor oil, 42.7 gallons at $0.601		25.66	.011
Rock drill oil, 36.2 gallons at $0.636		23.02	.010
Fuel: 78 tons coal at $8.41	$ 655.98		
820 pounds coke at $17.15 per ton	7.03	663.01	.281
Freight and haulage on supplies		196.91	.083
Repairs to machinery and equipment		134.22	.057
General and miscellaneous		99.40	.042
Total mine equipment and supplies		$2,930.40	$ 1.242
Mill:			
Materials of construction, tailings launder		8.60	$ 0.004
Xanthate, 850 pounds at 29 cents		246.50	.105
Pine oil, 275 gallons at 69 cents		189.75	.081
Fuel oil, 25 gallons at 12.1 cents		3.02	.001
Grinding balls, 3,454 pounds at $72.15 per ton		124.60	.053
Grease, etc		29.30	.012
Freight and haulage on supplies		139.25	.059
Repairs to machinery and equipment		77.65	.033
Weighing: 38 loads concentrates at 20 cents	$ 7.60		
12 loads miscellaneous at 20 cents	2.40	10.00	.004
Assaying and sampling at Leadville		42.95	.018
General and miscellaneous		47.61	.020
Total mill equipment and supplies		$ 919.23	$ 0.390
Total equipment and supplies for July 1937		3,849.63	$ 1.632

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TABLE 9. - Distribution of power cost, London-Butte Gold Mines Co., July 1937

Item	Monthly cost	Cost per ton
Mine: 25,000 kw.-hr. (arbitrary) at $0.01375.....	$ 343.85	$ 0.146
Mill: 70,040 kw.-hr. (balance) at $0.01375.....	963.36	.408
Total power for July 1937	$1,307.21	$ 0.554

TABLE 10. - Summary of operating costs, London-Butte Gold Mines Co., July 1937

	Labor		Supplies		Power		Total	
	Month	Per ton	Month	Per ton	Month	Per ton	Month	Per ton
Mine.....	$ 10,224.20	$ 4.333	$ 2,930.40	$ 1.242	$ 343.85	$ 0.146	$ 13,498.45	$ 5.721
Mill.....	1,930.42	.818	919.23	.390	963.36	.408	3,813.01	1.616
Superintendence...	1,000.00	.424	-	-	-	-	1,000.00	.424
Total.....	$ 13,154.62	$ 5.575	$ 3,849.63	$ 1.632	$ 1,307.21	$ 0.554	$ 18,311.46	$ 7.761

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Fairplay Gold Mines, Inc.

In September 1937 Fairplay Gold Mines, Inc., was operating the North London mine and mill under lease from The London Mines & Milling Co.[10] The main office of Fairplay Gold Mines, Inc., is at Fairplay, which is 5.6 miles by road southeast of Alma. The North London mine is near the head of Mosquito Gulch, about 8.2 miles by road west of Alma.

Information on mining and milling operations was kindly contributed by J. Price Briscoe, general manager, and by O. G. Carstens, general superintendent, to whom acknowledgment is gratefully made.

North London mine

The ore body at the North London mine is classified as belonging to the gold-quartz veins of the London type (see p. 15.) Most of the gold is in the pyrite, but there is some free gold in the quartz. The gangue is mainly quartz and quartzite, with a little limestone and gray porphyry. The presence of galena or chalcopyrite is considered a good sign. Many "pick" samples are taken daily by the mine foreman.

A main adit, known as the Blanchard crosscut, crosscuts the vein system on the Vienna level at an elevation of 12,285 feet. Below the Vienna level are three levels on the south side of the mine - the first, third, and fourth - at intervals of 75, 75 and 60 feet, respectively. On the north side of the mine is a second level, in addition to those mentioned. In September 1937 no mining was being done above the Vienna level. A development crosscut was being driven on the fourth level, and development raises were being driven from the third level.

In August 1937 ore from the south side of the mine produced 70 percent of the total value of ore mined. Both sides of the mine produced about equal tonnages; on the south side, 45 percent of the total production was from stopes on the fourth level and 5 percent from the third level; on the north side, 45 percent was from the second level and 5 percent from the third level. After reduction of the working force from 105 to 64 men on September 15, 1937, all the ore was being mined from the south side of the mine - 90 percent of it from stopes on the fourth level and 10 percent from the third level.

Ore from stopes on the south side is hand-trammed in 1,500-pound cars to 30-ton ore pockets at the south winze, which is vertical. There is a 6-inch grizzly over each pocket. The average length of tram on the fourth level is 200 feet; on the third level the average tram is 700 feet. A 1-1/2 ton self-dumping skip raises the ore to a 35-ton ore pocket on the Vienna level. The skip hoist is operated by a 35-horsepower motor; a 5/8-inch wire rope is used. An eight-car train of 1-ton cars is loaded from the ore

10/ The lease expired November 22, 1937, since which time the North London property has been operated by the London Mines & Milling Co.

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pocket at the south winze. A 1-1/2-ton storage-battery locomotive hauls the train about 3,700 feet to the portal of the main adit. The track is of 12-pound rails; the gage is 18 inches. The cars are dumped by hand into a trommel at the sorting plant (see fig. 12).

Before the curtailment in operations on September 15, 1937, ore from the north side of the mine was hand-trammed to the north winze; the average length of tram was about 1,000 feet on the second and third levels. At the north winze a 50-horsepower electric hoist raised the ore in a 2-ton skip to an ore pocket on the Vienna level. A 3/4-inch wire rope was used. The ore was loaded into 1-ton cars, which were pulled in 12-car trains 1,000 feet to the portal of the adit.

The following wage scale was in force at the North London mine in September 1937:

Miners, timbermen, hoistmen	$ 5.20
Shovelers, trammers timber helpers	4.40
Motormen, ore sorters, pipemen	4.95
Blacksmith and mechanic	5.75
Outside labor	4.00

At the mine portal are a compressor house, a blacksmith shop, a machine shop, a boarding house and bunk house, and several cabins. About 22 men live at the mine during the summer, 50 during the winter.

Water for domestic purposes and for the compressor and air drills is piped from a small lake just below Mosquito Pass. In the winter, snow is sometimes used.

There are two compressors - 1,000 cubic-foot compressor driven by a 150-horsepower motor and a 300-cubic-foot compressor driven by a 50-horsepower motor. Air is compressed to 100 pounds per square inch and delivered to a 4- by 10-foot receiver at the portal. A 4-inch main air line carries the air 1,000 feet into the main adit to a 3- by 10-foot receiver. This is followed by 1,500 feet of 3-inch line, then 2-1/2-inch and 2-inch lines. Air is conveyed to the stopes by 1-1/2-inch lines. The air pressure at the machines is about 75 pounds per square inch.

Electric power is delivered to the mine at 13,000 volts. It is stepped down and used at 440 volts and is 3-phase, 60-cycle.

Drifts and crosscuts are driven 4 by 7 feet in section. Drilling is done by a hammer drill mounted on a vertical column; 1-1/8-inch, round lugged steel is used. Starting bits are 2-1/4 inches in diameter and following diameters decrease by 1/8-inch. A center-cut or a draw-cut arrangement of holes ordinarily is used. Rounds are not standardized; 12 holes are required in porphyry, 14 in limestone, and 20 in quartzite. From 60 to 85 sticks of 45-percent-strength gelatin dynamite are used per round. A round breaks about 4 feet.

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An electric locomotive hauls water for drilling to a pressure tank at the head of the south winze. From the tank it is piped to the working places.

Waste from development is dumped into stopes.

The mining method used at the North London mine is open stoping. The veins dip at about 70°. The width of ore mined is irregular but averages about 4 feet. Stulls are used to support the miners. Chutes are spaced at 25-foot intervals. Chute gates are of the conventional board type, 3 feet wide. Lagged manways are carried up with alternate chutes, making them 50 feet apart.

A miner drills about 14 holes per shift, using a stoping drill with 1-inch hollow quarter-octagon steel. Holes are drilled 3-1/2 feet in depth and loaded with about three sticks of 45-percent-strength gelatin dynamite. A 14-hole round breaks about 5 tons. The broken ore is deflected to the chutes by wing stulls. Miners obtain their steel at the winze station, where it is delivered by the motor.

Jackhammers occasionally are used for trimming and blockholing. They employ 7/8-inch hollow hexagon steel.

North London mill

The North London mill of Fairplay Gold Mines, Inc., is on the southwest bank of North Mosquito Fork, 1.8 miles by road below the mine, with which it is connected by an aerial tramway 3,300 feet long. The mill is a 100-ton unit of the side-hill type. It was operated at full capacity just before September 15, 1937, when the night shift was eliminated and the tonnage treated was reduced to 65 tons in two shifts. The flow sheet is shown in figure 12.

The original mill at the North London property was a cyanide plant. It was a failure on account of the black carbonaceous shale in the ore. Flotation was then tried and proved successful. The North London mill was the first flotation concentrator in the Alma district.

The ore treated in the mill has been classified as belonging to the London type of gold-quartz veins (see p. 15). In September 1937 about 90 percent of the ore was extremely hard, owing to its source in the highly silicified quartzite-limestone contact.

Ore is brought out of the mine in trains of 1-ton cars. It is minus 6 inches in diameter, since it passed through 6-inch grizzlies over the mine ore pockets. The 1-ton mine cars are dumped by hand into the end of a 3- by 10-foot trommel equipped with a 2-1/4-inch screen. The oversize runs into a 15-ton bin, from which it is let out slowly enough to permit waste to be sorted out at the chute. Fifteen to 18 percent of the ore mined is thrown out for waste. The sorted ore runs down the chute into a

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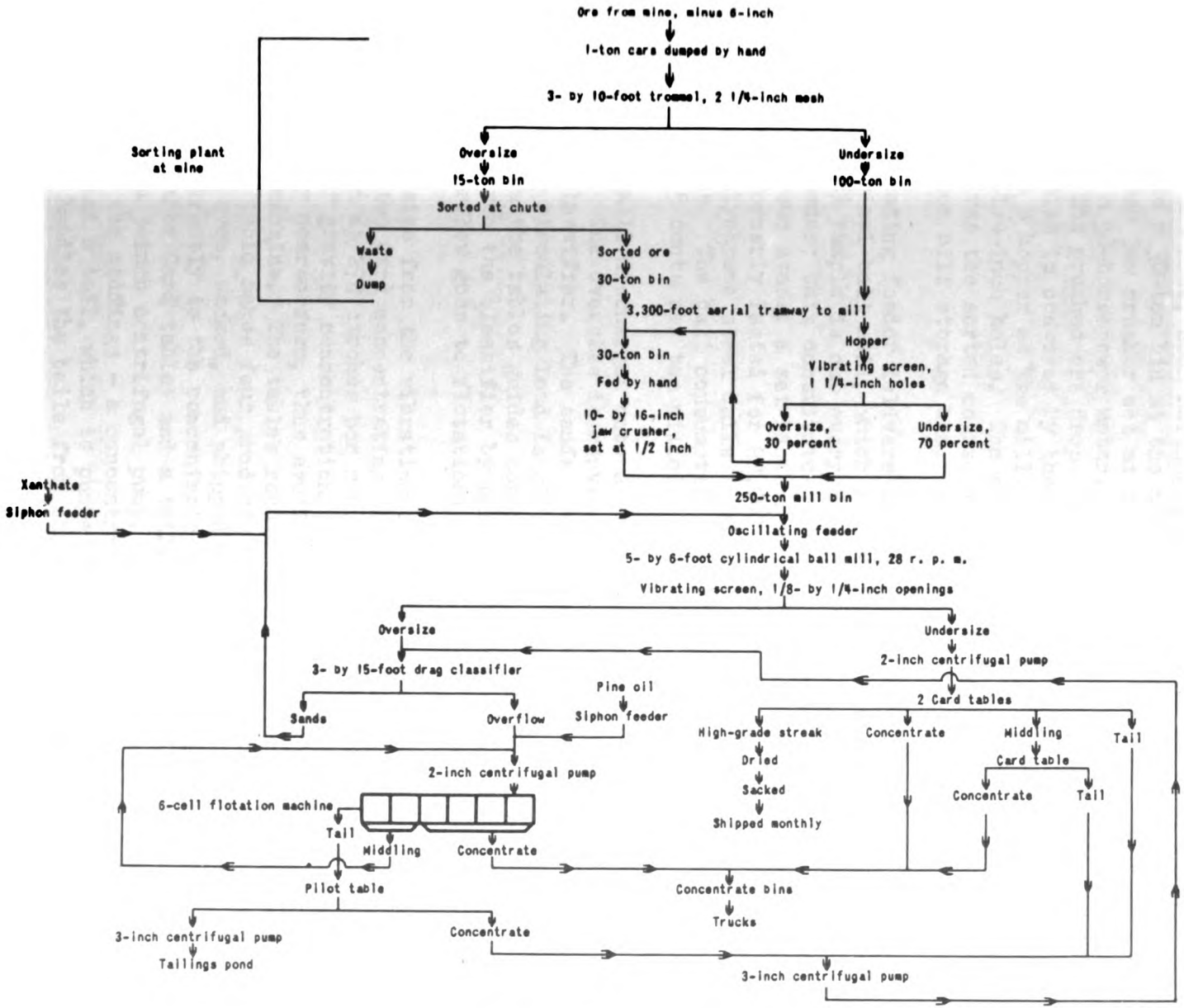

Figure 12.- Flow sheet of North London mill.

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30-ton bin. The trommel undersize drops into a 100-ton bin. From these two bins an aerial tramway 3,300 feet long conveys the ore to the mill. The vertical drop from the mine to the mill is about 800 feet. There are 15 buckets on the line, each holding 800 pounds. The sorted coarse ore is delivered to a 30-ton bin at the mill, from which it is fed by hand to a 10- by 16-inch jaw crusher set at 1/2 inch. The crusher is driven at 275 r.p.m. by a 30-horsepower motor. Tramp steel is picked out by the crusher man. The crushed ore drops into a 250-ton mill storage bin. The trommel undersize is conveyed by the aerial tramway from the 100-ton bin at the mine to a hopper at the mill. The hopper feeds into a vibrating screen with 1-1/4-inch holes. The screen oversize drops into the 30-ton bin that receives the sorted coarse ore from the mine; the undersize drops into the 250-ton mill storage bin.

An oscillating feeder delivers the ore from the mill bin to a 5- by 6-foot cylindrical ball mill, which is driven at 28 r.p.m. by a 100-horsepower motor. A sample is cut every 20 minutes from the stream of ore leaving the feeder; this constitutes the head sample. The ball-mill liners are of molychrome steel; a set lasts for 28,000 tons of ore. Manganese-steel liners formerly lasted for 22,000 tons of ore. Grinding is done by 4-inch cast-molychrome steel balls weighing 9 pounds each. The ball load is 6,000 pounds. The ball consumption is 54 balls for a 24-hour run; it amounts to 14.5 cents per ton milled.

The ball mill discharges onto a vibrating screen with 1/8- by 1/4-inch openings. The oversize is conveyed in a short launder to a 3- by 15-foot drag classifier. The sands from the classifier are returned to the ball mill; the circulating load is 200 percent. Pulp density is not measured; the recovery on the tables guides correct operation. Xanthates are added to the sands from the classifier by a siphon-type reagent feeder. The classifier overflow goes to flotation.

The undersize from the vibrating screen is pumped by a 2-inch centrifugal pump to two Card concentrating tables arranged in parallel. Each table is driven at 270 strokes per minute by a 1-1/2-horsepower motor. The function of gravity concentration is to recover the valuable minerals in a relatively coarse form, thus avoiding excessive sliming and relieving the flotation machine. The tables recover 1/2 to 2/3 of the total gold recovered. Each table makes four products: A streak of high-grade, which is dried in an oven, sacked, and shipped once a month; a concentrate, which is delivered directly to the concentrate bins; a middling, which is retreated on another Card table; and a tail, which is pumped back to the classifier by a 3-inch centrifugal pump. Two products are made by the table treating the middlings - a concentrate, which is delivered to the concentrate bin; and a tail, which is pumped back to the classifier by the same pump that handles the tails from the two preceding tables.

The classifier overflow (minus 60-mesh) is pumped by a 2-inch centrifugal pump to the first cell of a six-cell flotation machine. Pine oil is added to the classifier overflow by a siphon-type reagent feeder. The total cost of reagents is usually about 7.8 cents per ton of ore. The

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first four cells of the flotation machine make a concentrate, which is delivered to the concentrate bins. The last two cells make a middling, which is pumped with the classifier overflow to the first cell. The tail from the flotation machine is passed over a pilot table. The concentrate made on the table is pumped back to the classifier with the tails from the other tables. The tail from the pilot table is automatically sampled and pumped to the tailings pond by a 3-inch centrifugal pump. The pond overflows into a 6-inch pipe. It is proposed to run the tailings over the hillside above the pond (that is behind the dam) during the winter months to permit the slide rock and underbrush to hold back the slimes, which cannot be settled satisfactorily in the pond during freezing weather.

All motors in the mill operate on 440-volt, 3-phase, 60-cycle current and are equipped with multiple V-belt drives.

Water for milling and for domestic purposes is brought from Mosquito Creek to the foot of the mill in a flume. A triplex pump delivers it to the mill distribution tanks.

Only two mill employees live at the property; the others live in Alma or Fairplay. When the mill was running three shifts before elimination of the night shift on September 15, 1937, 14 men were employed, as shown in table 11.

TABLE 11. - Mill labor, North London mill, September 1, 1937

Number	Occupation	Daily	
		Wage	Cost
1	Mill foreman.....	$ 6.50	$ 6.50
3	Shift bosses.....	5.00	15.00
3	Ball-mill men.....	4.25	12.75
3	Flotation men.....	4.25	12.75
1	Tailings-pond man.....	4.25	4.25
1	Tramway operator.....	4.50	4.50
1	Assayer.....	5.50	5.50
1	Sample boy (helps assayer)..	4.25	4.25
14	-	-	$65.50

A cook, at $50 per month and room and board, is also charged to the mill.

Table 12 is a smelter settlement sheet dated July 23, 1937; it shows the method of payment for a lot of mixed (table and flotation) concentrates:

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TABLE 12. - Smelter settlement sheet

Quotations of July 14, 1937: Silver, 77 cents per ounce.
Lead, 6 cents per pound.

Assay

	Gold	Silver	Lead	Copper	Insoluble	Iron	Zinc
American Smelting & Refining Co.....	3.30	4.0	3.1	-	-	-	-
Mine	3.325	3.64	3.5	-	-	-	-
Settlement	3.3125	3.82	3.3	0.0	8.2	38.1	2.8

Wet weight: 86,840 pounds. Dry weight: 78,156 pounds
Moisture: 10 percent

Payment per ton		Deductions per ton	
Gold at $32.31825.....	$ 107.05	Base charge	$6.00
Silver, 95 percent, 1.5...	2.74	Insoluble at 10 cents ...	.82
Lead, 1.5, 75 percent, 0.90	1.22	Iron credit at 10 cents..	3.81
Total payments	$ 111.01	Total deductions	$3.01
Less total deductions ..	3.01		
Net payment	$ 108.00		

39.078 tons at $108	$ 4,220.42
Switching	5.40
Hauling at $4.50 per ton	195.39
Royalty at 10 percent	409.02
Net proceeds	$ 3,610.61

The method of payment for a shipment of sacked "high-grade" from the tables is shown in table 13, which is a smelter settlement sheet dated August 20, 1937:

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TABLE 13. - Smelter settlement sheet

Quotations of August 2, 1937: Silver, 77 cents per ounce
Lead, 6.292 cents per ounce

	Gold	Silver	Lead	Insoluble	Iron	Zinc
American Smelting & Refining Co.....	41.00	18.0	28.1	1.2	32.0	0.0
Mine.....	42.003	17.965	29.65	-	-	-
Metallics.....	4.019	1.241	-	-	-	-
Settlement.....	45.5205	19.2235	28.875	1.2	32.0	0.0

Wet weight, sacked:	6,416 pounds
Sacks:	34
Wet weight:	6,382 pounds
Moisture, 1 percent:	64
Dry weight:	6,318 pounds

Payment per ton		Deductions per ton	
Gold.....	1,520.98	Base charge.....	$ 6.00
Silver.....	13.78	Insoluble.....	.12
Lead.....	19.67	Iron, credit.....	3.12
Total payment.....	1,554.43	Minimum charge.....	$ 3.00
Less total deductions.	3.00		
Net payment.....	$ 1,551.43		

3.159 tons at $1,551.43 per ton.....		$ 4,900.97
Haulage.....	$ 14.43	
Handling sacks at $1 per ton.....	3.21	
Sampling.....	5.00	
Royalty at 10 percent.....	488.31	510.95
Net proceeds.....		$4,390.02

Metallurgical data for the month of August 1937 are given in table 14:

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TABLE 14. - Metallurgical data

Plant: Fairplay Gold Mines, Inc.
Period covered: Month of August 1937.

Ore from mine.....	3,440 cars		
Waste sorted out....	540		
Ore to mill.....	2,900 cars...	7,355 tram buckets..	2,942 tons (wet)
Ore milled.....			2,815 tons
Moisture .....percent..			2.3

	Dry tons	Gold, ounces per ton
Heads.....	2,756.375	0.318
High-grade streak from tables...	3.965	43.01
Table and flotation concentrates	267.057	2.431
Tailings.....	2,485.353	.023

Ratio of concentration.....		10.335
Recovery.....	percent....	93.762
Operating time.....do.....		94 (approx.)
Reagent consumption:		
Z-4.....	850 pounds.....	$135.09
Pine oil.....	87.45 gallons	61.25

Monthly production data for the North London mine during the first half of 1937 are given in table 15. The total length of development drifts and crosscuts driven during the period was 1,461 feet, an average of 243.5 feet per month.

The gross value of the concentrates made during the period, before smelting charge, freight, etc., were deducted, was $170,009.67, or about $123.53 per ton. Concentrates as shipped usually contain about 9 percent moisture.

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TABLE 15. - Production of North London mine, January 1 to June 30, 1937

Month	Ore to mill (wet tons)	Waste from development and sorting	Concentrates made (dry tons)
January	2,556.28	1,197	49.816
February	2,560.32	1,158	164.929
March	2,819.72	1,400	309.826
April	2,792.72	1,169	282.457
May	2,941.52	1,492	250.427
June	3,049.72	1,575	138.029
Difference in bin	44.56	-	180.802
Total	16,764.84	7,991	1,376.286
	-	16,765	-
Total tons broken in mine	-	24,756	-

Costs

The distribution of costs at the North London mine and mill for the 6-month period January 1 to June 30, 1937, is shown in table 16. During the period 24,756 tons of ore and waste were broken in the mine, of which 16,765 tons were milled.

West London Mine

In September 1937 the West London Mining & Leasing Co. was subleasing from the Fairplay Gold Mines, Inc. It was following a streak of high-grade ore in the Middle tunnel, above the North London mine. The crew consisted of a lessee and three miners. Shipments of ore were made to the Leadville smelter by truck. Royalty was paid directly to The London Mines & Milling Co. by agreement with the Fairplay Gold Mines, Inc., since the latter company was mining ore from property owned by the West London Mining & Leasing Co.

London Extension Mining Co.

In September 1937 the London Extension Mining Co. was mining and milling the old South London dump under lease from the South Mosquito Mining & Milling Co., owners. Operations were begun August 7, 1937. The dump is estimated to contain 178,000 tons.

Grateful acknowledgment is made to J. N. Redman, general manager, Harry Bishop, general superintendent, and S. J. Bartula, mill superintendent, for information on company operations.

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TABLE 16. - Cost distribution, North London mine and mill,

January 1 to June 30, 1937

	Cost	Cost per ton broken	Cost per ton milled
Mine:			
Labor	$ 79,896.27	$ 3.22	$ 4.77
Supplies	12,531.68	.51	.75
Machine repairs	3,400.49	.14	.20
Machine rentals	300.00	.01	.02
Power	4,861.22	.20	.29
Total mine	$ 100,989.66	$ 4.08	$ 6.03
Mill:			
Labor	$ 12,764.65	0.52	0.76
Supplies	5,896.84	.24	.35
Machine repairs	865.02	.03	.05
Power	4,562.81	.18	.27
Total mill	$ 24,089.32	$ 0.97	$ 1.43
Overhead:			
Operating:			
Superintendence	$ 2,026.25	$ 0.08	$ 0.12
Compensation insurance	5,301.92	.22	.32
Royalties	15,027.08	.61	.90
Smelting charge	4,570.57	.18	.27
Freight and haulage	7,561.34	.30	.45
Total operating overhead	$ 34,487.16	$ 1.39	$ 2.06
General:			
Office salaries	$ 4,910.00	0.20	$ 0.30
Office expense	1,072.51	.04	.06
Engineering and assaying	678.15	.03	.04
Legal and professional	859.64	.03	.05
Travel and entertainment	508.99	.02	.03
General taxes	872.80	.04	.05
Social security and unemployment insurance	3,036.89	.12	.18
Total general overhead	$ 11,938.98	$ 0.48	$ 0.71
Total	171,505.12	$ 6.92	$10.23

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South London Dump

The dump was mined by a dragline mounted on crawler treads and equipped with a 40-foot boom and a 1-cubic-yard bucket. From a position on the flat top of the dump the dragline excavated the edge of the dump to a depth of 20 feet, retreating as excavation proceeded. This would result in removing a horizontal slice 20 feet deep from the top of the dump. The dragline excavated 650 buckets in about 10 hours. The material was dumped into trucks. A truck held three or four buckets, considered about a 5-ton load. Dump ore is estimated to weigh 1.75 tons per cubic yard. On September 23, 1937, two trucks hauled 124 loads, averaging 5 tons per load. The trucks delivered the dump ore to a bin at the upper end of a screening and sorting plant; the truck haul was a quarter of a mile up a 6-percent grade.

The work of excavating and hauling is done on contract. The contractor furnishes the dragline and guarantees 600 tons per day of 12 hours. The truck drivers furnish their trucks and are paid 6 cents per ton hauled.

Sorting Plant

The sorting plant is a quarter of a mile from the dump; a flow sheet of the plan is shown in figure 13. The trucks dump the dump ore on a 6-inch grizzly over the top of a 15-ton bin. The grizzly is made of railroad rails and slopes at 45°. The oversize is hand-sorted at the lower end of the grizzly; about 90 percent of it is thrown into a 1-ton mine car and dumped for waste. The other 10 percent of the oversize is sledged through the grizzly into the 15-ton bin with the undersize. A pan feeder delivers the ore from the bin to a 16-inch belt conveyor, which raises it up a 20° slope 75 feet long to the top of a 400-ton bin. From this bin a pulsating feeder delivers the ore to another 16-inch belt conveyor 60 feet long, which carries it up a 20° slope to a vibrating screen having 1-1/4-inch openings. The oversize is delivered to a 40-inch sorting belt 25 feet long. Four sorters pick out about 20 percent of the material for ore and throw it into chutes which feed a 16-inch conveyor belt. This belt also receives the undersize from the vibrating screen; it conveys the material up a 20° slope 100 feet long to the tramway bin at the shaft of the American mine. The mill capacity is less than the output of the sorting plant. To adjust the difference a cut is taken intermittently from the end of the conveyor above the bin by means of a 1-ton mine car. The loaded car is trammed about 200 feet and dumped on a stock pile. The 80 percent of the screen oversize left on the sorting belt is discharged onto a 16-inch belt conveyor that carries it 100 feet up a 20° slope to a horizontal 16-inch conveyor 50 feet long, which distributes it over the waste dump.

Mill

The sorted ore, representing about 65 percent of the dump material, is transported by an aerial tramway to a 100-ton mill. The tramway is 4,400 feet long; the buckets hold 500 pounds. The mill was built in 45 days. It began operations August 7, 1937. About 135 tons of sorted dump ore is treated per day; the flow sheet is shown in figure 14. The ore is dumped

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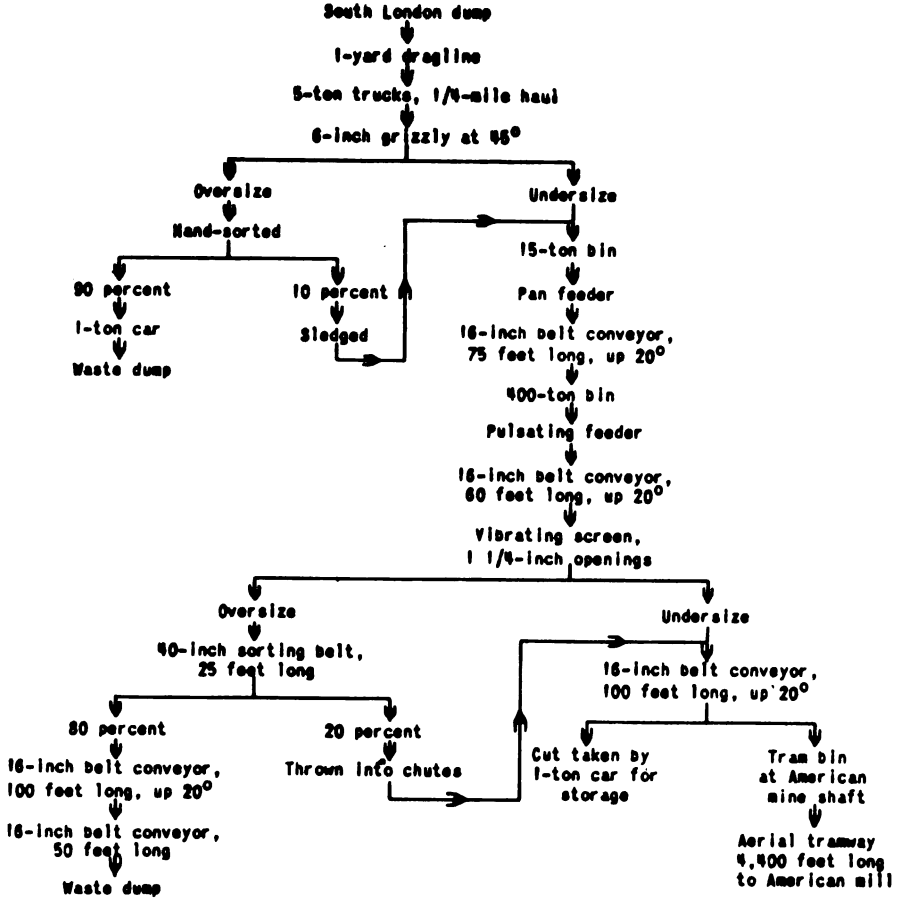

Figure 13.- Flow sheet of sorting plant, London Extension Mining Co.

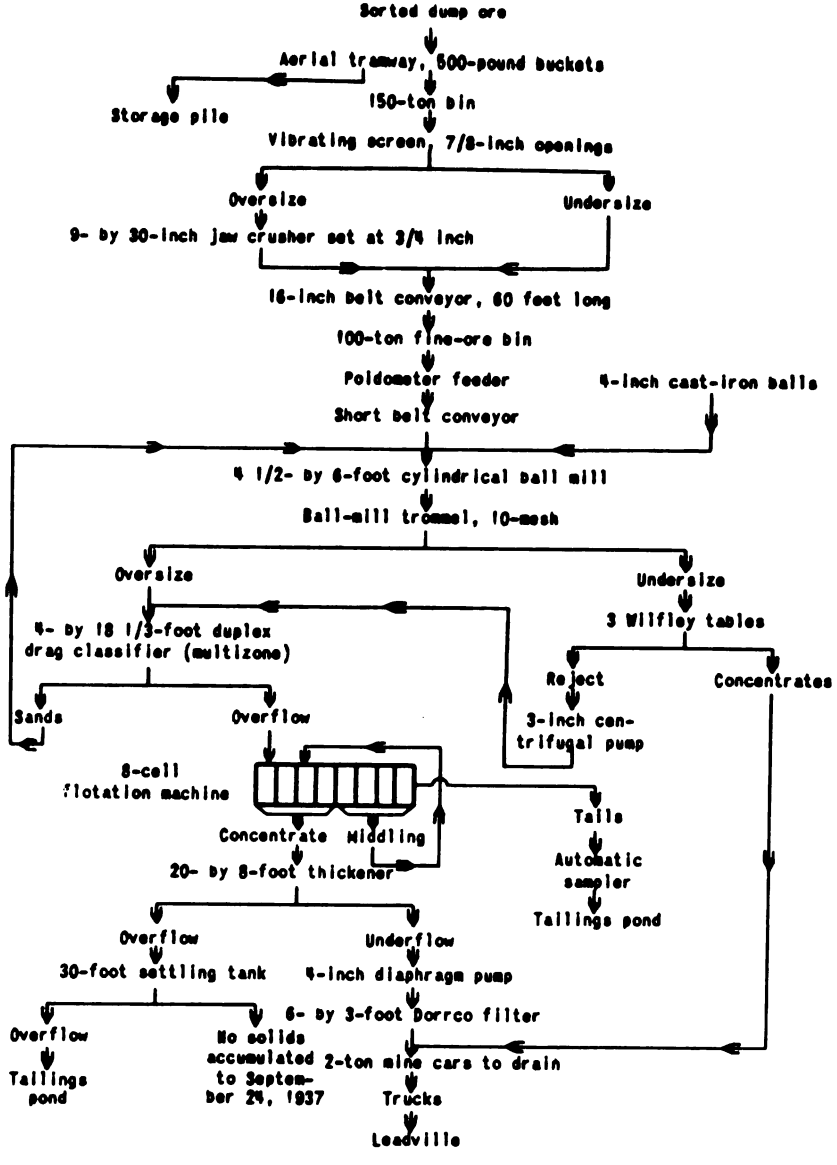

Figure 14.- Flow sheet of mill, London Extension Mining Co.

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into a 150-ton bin at the head of the mill, from which it is fed to a vibrating screen having 7/8-inch openings. The screen oversize is fed to a 9- by 30-inch jaw crusher driven at 250 r.p.m. by a 25-horsepower motor. All motors in the mill are 440-volt. The crusher is set at 3/4 inch. The crushed ore joins the screen undersize on a 16-inch belt conveyor 60 feet long, which discharges into a 100-ton fine-ore bin. A small pan conveyor cuts a continuous sample from the discharge of the belt conveyor; this is the head sample. From the fine-ore bin a poidometer feeder weighs the ore and delivers it to a short belt conveyor that feeds a 4-1/2- by 6-foot cylindrical ball mill. The ball mill uses 4-inch cast-iron balls, which are consumed at the rate of about 2 pounds per ton of ore. The ball mill is equipped with a 10-mesh trommel, the oversize from which passes into a duplex multizone drag classifier 4 feet wide by 18 feet 4 inches long. The trommel undersize is divided among three Wilfley tables. The table concentrates are discharged into 2-ton mine cars to drain; they are later shipped to the American Smelting & Refining Co. at Leadville. The table rejects are pumped to the classifier by a 3-inch centrifugal pump. The sands from the classifier are returned to the ball mill, closing the circuit. The classifier overflow is conveyed in a launder to the first cell of an 8-cell flotation machine. The first four cells make a concentrate; the remaining four cells make a middling that is returned to the third cell. The tailings pass through an automatic sampler and then to the tailings pond. The flotation concentrates are thickened in a 20- by 8-foot thickener. A 4-inch diaphragm pump raises the thickened underflow to a 6- by 3-foot Dorrco filter. The filter cake is discharged into the same 2-ton mine cars that receive the table concentrates. About 60 percent of the concentrates are made on the tables and 40 percent in the flotation machine; they are of approximately equal grade. After draining, the mixed concentrates, containing 10 to 12 percent moisture, are dumped into trucks for shipment to Leadville. The concentrates are pipe-sampled in the trucks. The 20- by 8-foot thickener overflows into a 30-foot settling tank to clear and store the water for re-use. The settler overflows into the tailings pond. To date (September 24, 1937) not enough solids have accumulated in the settler to necessitate removal.

The mill recovers about 90 percent of the gold in the ore. The ratio of concentration is 18 to 22 : 1.

In September 1937 flotation reagents were used as follows:

"208": A resulfidizing agent; 0.10 pound per ton, added to the ball-mill feed by a siphon-type feeder.

Z-4: 0.15 pound per ton, added by a rotating-bucket type of feeder, to the pump box of the 3-inch pump that pumps the table rejects to the classifier.

Z-6: 0.09 to 0.10 pound per ton, divided between no. 1 and no. 4 cells.

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Aerofloat: 0.21 pound per ton, distributed among cells.

Cresylic acid: 0.05 pound per ton.

Pine oil: None used.

In September 1937 the mill worked three shifts per day. Labor consisted of 3 operators and 3 helpers, 3 men at the tailings pond, 1 crusher man, 1 mechanic, and 1 sample boy, a total of 12 men per day.

The aerial tramway worked two shifts per day. Two men were employed at each terminal, making a total of eight men per day on the tramway.

Operations have not continued over a long enough period to permit the establishment of definite costs. The following approximate costs have been estimated by the management:

	Per ton
Excavating and trucking dump ore to bin.....	$ 0.40
Sorting and conveying by aerial tram to mill..	.80
Milling.....	1.50
Marketing.....	.60
Tailings loss (average assay of tailings is 0.025 ounce of gold per ton).....	.80 to .90

American Mine

The American mine is on London Mountain at an elevation of a little over 12,000 feet. The information on company operations was kindly furnished by Chas. Vetter, mine superinetndent.

The ore occurs as quartz veins of the London type (see page 15). The wall rock at the American mine is porphyry.

Surface buildings include a compressor house, shops, office, a bunk house, and a boarding house. Water for the camp is obtained from a diamond-drill hole on the third level of the mine. A centrifugal pump on that level pumps the water to a tank on the first level, from which another centrifugal pump delivers it to a tank on the surface.

A four-drill compressor driven by an 80-horsepower motor supplies air at a pressure of 110 pounds per square inch to a receiver on the surface. A 4-inch main air line carries the air to another receiver on the second level. Two-inch air lines lead from the latter and are reduced to 1-inch for the branch lines.

Power is received at 13,000 volts; it is stepped down to 440 volts for the motors.

Underground development includes extensive lateral workings reached through a two-compartment vertical shaft which extends to the third level,

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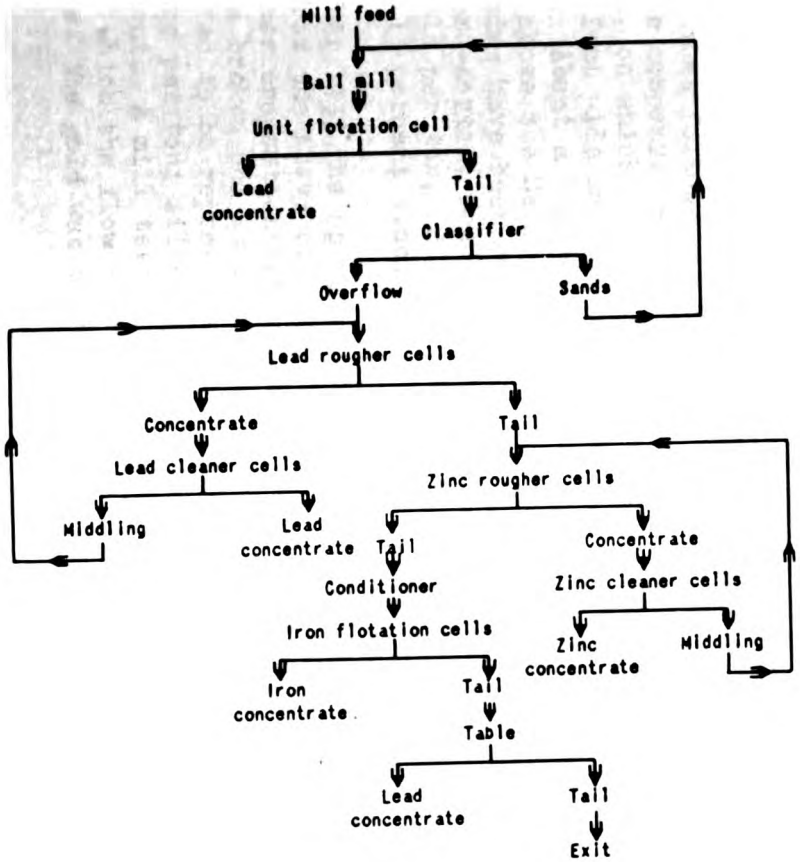

Figure 15.- Proposed flow sheet of Alma-Betts mill.

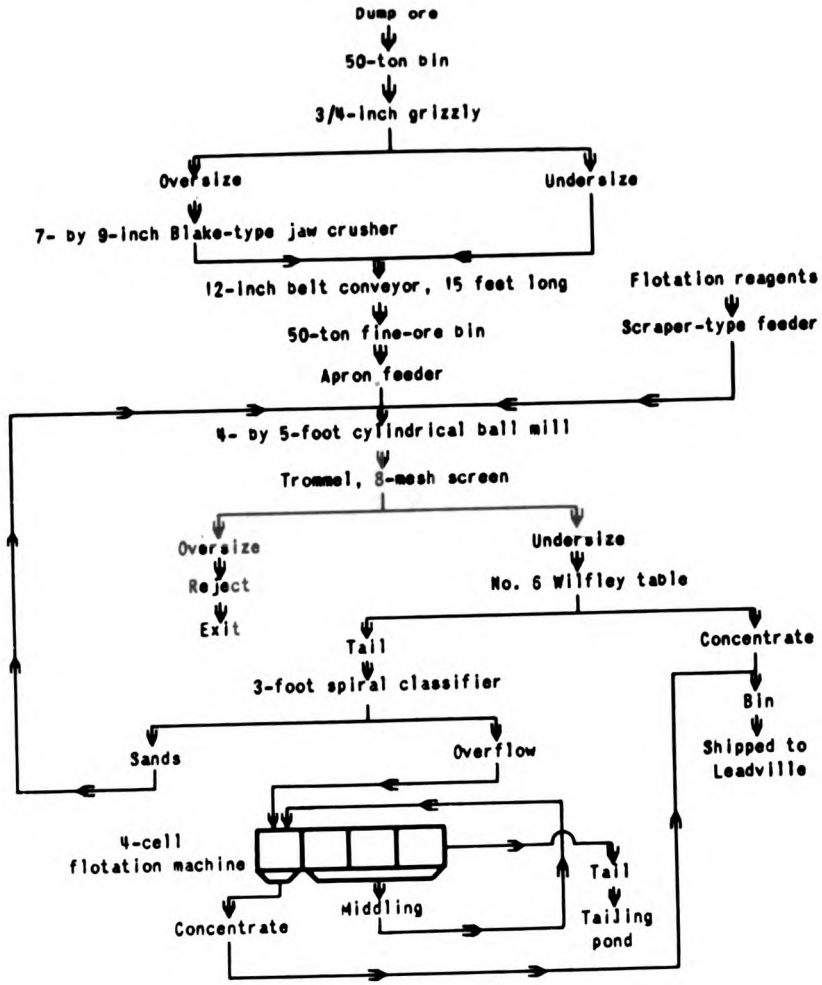

Figure 16.- Flow sheet of Hock Hocking mill.

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370 feet below the collar. The hoisting compartment is 4-1/2 by 4-1/2 feet and accommodates a single-deck cage; the hoisting cable is 1 inch in diameter.

In September 1937 the mine was operated one shift per day by W. A. Ellis, Inc., of Denver, Colo. Fifteen men were employed in the mine and five on the surface. The work consisted of extending old stopes and extracting pillars of ore that had been left by former operators. Close sampling was necessary. The ore in the leads from the old stopes was about 1 foot wide and was mined by stripping. About 3 feet of waste under the ore was first shot out and disposed of; then the ore was broken down. On account of the variety of conditions under which the ore occurred, drill rounds were not standardized. Drilling was done with wet drifters using 1-1/8-inch hollow round steel, stopers using 1-inch hollow hexagon steel, or jackhammers using 7/8-inch hollow hexagon steel, whichever was most convenient for the particular round. Holes usually were drilled 5 feet deep and loaded with two to four sticks of 45-percent-strength gelatin dynamite. Each working place yielded 300 to 400 pounds of ore per shift. The broken ore was transferred by wheelbarrow to a nearby chute; the average distance was about 75 feet. It was then trammed in a 1-ton mine car about 300 feet to the shaft and hoisted. Waste was handled by the same procedure; 40 to 50 cars of waste was hoisted per day.

In September 1937 miners and timbermen received $5.25 per day; helpers, $4.50 per day.

Alma-Betts Mining Co.

The Alma-Betts Mining Co. controls through bond and lease a number of small properties in Mosquito Gulch about 1 mile southwest of Park City. The information that follows was kindly contributed by C. S. Van Deman, president of the company. At the Dauser mine a 400-foot adit intersects the Dauser vein, on which about 300 feet of drifting has been done. The vein is 2 to 3 feet wide and has been stoped for a height of 50 feet in several places. About a hundred feet of crosscutting has been done. A short distance above the Dauser claim are the Susquehanna and Juniata claims. These three claims have been mined in a desultory way in the past. The ore has been hand-sorted, resulting in a shipping product that assayed about 0.5 ounce of gold per ton, 12 to 20 ounces of silver per ton, 25 to 30 percent lead, and 13 percent zinc.

In September 1937 the operating company was equipping a 50-ton mill to treat ore from the above claims, from 171 acres of patented ground nearby and from other properties controlled by the company. About 5,000 tons of mill ore was broken and awaiting completion of the mill. A 400-pound sample, estimated to be representative of the mill heads, assayed as follows: Gold, 0.28 ounce per ton; silver, 3.8 ounces per ton; lead, 6.2 percent; zinc, 5.7 percent. A mill test was made on this sample on August 14, 1937, as a result of which the flow sheet shown in figure 15 was recommended. A good recovery of the gold was made. Part of the lead is oxidized and slimes,

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and since the silver is associated with the lead, some silver as well as lead was lost. The zinc appeared to be activated and therefore was not successfully depressed when the lead was floated. The iron sulfides carried over 10 percent of the total gold.

Hock Hocking Mine

The Hock Hocking mine is about a mile southwest of Park City. For some years narrow quartz veins have been mined on the limestone-granite contact. The ore contains silver, some native and some with galena and sphalerite; gold with pyrite; and a little cerussite.

In September 1937 the property was controlled through a bond-and-lease agreement by C. F. Dandois, who kindly contributed the information on current operations. The mine was not being worked at that time, although about 15,000 tons of ore had been blocked out on three sides. An additional 1,000 tons was broken underground. Operations were limited to milling dump ore, the plan being to treat ore from the mine when winter weather interfered with dump operations.

The main dump contained about 7,000 tons, and a smaller and more accessible dump contained 500 tons. On September 11, 1937, a 50-ton mill started treating 30 tons a day from the small dump. The flow sheet is shown in figure 16. The tonnage was soon to be increased to capacity, and then the main dump was to be treated, taking the best parts first. The ore from the small dump assayed about 0.03 ounce of gold per ton, 9 ounces of silver per ton, and a small amount of lead. The ore was shoveled into a 1-ton mine car at the bottom of the dump. The car was dumped directly into a truck on the mine road. The truck haul to the mill bin was a quarter of a mile, with a rise of 100 feet in elevation. The truck dumped the ore into a 50-ton bin, from which it was discharged onto a 3/4-inch grizzly. The grizzly oversize was fed into a 7- by 9-inch Blake-type jaw crusher set at 3/4 inch. The crushed ore and the grizzly undersize dropped to a 12-inch belt conveyor 15 feet long that discharged into a 50-ton fine-ore bin. An apron feeder delivered the fine ore from the bin to a 4- by 5-foot cylindrical ball mill. A scraper-type reagent feeder fed the flotation reagents into the feed box of the ball mill. The following reagents were used: 0.2 pound of xanthate 301 and 0.15 pound of Aerofloat 31 per ton of ore, plus a variable amount of cresylic acid. The ball mill was equipped with a trommel having an 8-mesh screen. The trommel oversize was rejected; it was used on the mine road. The undersize was conveyed in a launder to a No. 6 Wilfley table. The table concentrate was delivered to a concentrate bin for shipment. The table tail passed to a 3-foot spiral classifier, the sands from which were returned to the ball mill. The classifier overflow entered the first cell of a four-cell flotation machine. The product of the first cell was a concentrate; it was delivered to the same bin with the table concentrates. The last three cells of the flotation machine made a middling product that was returned to the first cell. The flotation tails flowed into the tailings pond.

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Concentrates were loaded from the bin into trucks which hauled them to the smelter of the American Smelting & Refining Co. at Leadville. Assays of concentrates made in September 1937 averaged about 1.2 ounces of gold per ton, 150 ounces of silver per ton, 20 percent lead, 19 percent zinc (zinc over 10 percent was penalized), 5 percent insoluble, and 10 to 12 percent iron. After haulage, treatment charges, and 10 percent royalty were deducted the net amount received was about $115 per ton of concentrates.

Water for milling flows out of the main adit of the mine directly into the mill storage tank.

In September 1937 the mill force consisted of one superintendent, one mechanic, three operators at $4.50, and three helpers at $3.85.

Power for the mill was supplied by an 85-horsepower, 3-cylinder Diesel engine, which consumed 150 gallons of oil per 24 hours (three shifts).

The total cost of milling was estimated at $2.50 per ton.

Newbonnet Mines, Inc.

In September 1937, Newbonnet Mines, Inc., was driving a 5- by 7-foot prospect adit at Park City. The information on current operations was kindly contributed by J. Price Briscoe of Fairplay, under whose direction the work was done. The portal of the adit was in blue limestone, and the adit was being driven westerly into Loveland Mountain, crosscutting the sediments in their easterly dip. The length of the adit at that time was 1,618 feet.[11/] A small compressor at the portal, driven by a Stutz 8-cylinder gasoline engine, supplied air for drilling at 85 pounds per square inch. A 2-inch main air line was used. Work was done on one shift by a crew of four men, consisting of one compressor man, one machine man, one helper, and one mucker. A 13-hole round was drilled in a shift, using a drifting machine mounted on a vertical column. Detachable bits were used. Water for drilling was obtained in the tunnel and used in a pressure tank. Holes were loaded with 45-percent-strength gelatin dynamite. A round required 35 to 60 pounds and broke a little over 3 feet. The broken rock was hand-trammed to the dump. Track rails were 20-pound; the gage, 18-inch. The tunnel was ventilated by an exhaust fan at the portal, using 8-inch sheet-iron tubing.

Pierce and Siemon Lease

The property embraced in the Pierce and Siemon lease is on the south side of Buckskin Gulch on Loveland Mountain about 3 miles by road west of Alma. In September 1937 Fred M. Pierce and John W. Siemon were leasing the Union No. 5, Chicago, Rock Island, and Dodge Union claims from the owners. The information on their operations was kindly contributed by Siemon.

A main adit was driven into the face of a cliff on Loveland Mountain; it followed a vertical vein for 300 feet southwesterly. The adit was about

11/ On July 6, 1938, the length of the adit was 1,780 feet.

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5 by 7 feet in section; it was untimbered, except for seven sets of round timber at the portal. From the adit two vertical raises had been driven through a flat-dipping contact of schist (below) and quartzite (above). The first raise was 100 feet in from the portal; it was up 35 feet. At the top of the raise, in the quartzite, was an open stope; it was about 25 feet high and extended along the vein for about 40 feet. The width of the stope ranged from 18 inches to 4 feet. The ore minerals comprised mainly pyrite with some galena and a little chalcopyrite; the sulfides carried about 1 ounce of gold and 2 to 5 ounces of silver per ton.

One miner with hand steel broke about a ton of ore per day. Drill steel was 3/4-inch octagon. Four lengths of steel were used; starters were 1 foot long with a 1-3/8-inch bit; sizes of following bits decreased by 1/8-inch; finishers were 3 feet long with a 1-inch bit. Holes were drilled about 20 inches deep. A miner drilled four or five holes in ore per day. When it became necessary to drill in the barren quartzite for working width, only three holes were drilled per day. Holes in ore were loaded with about 2-1/2 sticks of 7/8- by 8-inch 40-percent-strength gelatin dynamite. The broken ore was shoveled into a chute 25 feet beyond the manway raise and loaded into a 1-ton car on the main adit. The track was of 16-pound rails.

The second raise from the main adit was 211 feet from the portal; it was 35 feet high. From the top of the raise an open stope 45 feet high extended along the vein for about 50 feet. The ore in this stope was oxidized; it was softer, lighter in weight, and somewhat narrower than that in the first stope. A miner could drill 8 to 10 holes 28 inches deep in a day. A miner broke about a ton of ore per day. The vein in this stope was 1 to 2 feet wide; cut samples assayed 4 ounces of gold per ton. The ore as broken, however, assayed 2 to 3 ounces of gold per ton.

Ore broken in the stopes was hand-trammed to the portal, where it was shoveled out of the car into a 1-ton aerial tramway bucket. The bucket was suspended from a 1-inch track cable which extended from the portal of the main adit to a 25-ton bin on the mine road. The cableway was 600 feet long, the slope 30° in favor of the loads. A Chevrolet motor geared to a converted hand winch moved the bucket along the track cable by means of a 1/2-inch steel tow rope. Trucks were loaded from the bin and hauled the ore to the smelter of the American Smelting & Refining Co. at Leadville. The haulage rate was $4.60 per ton. The cableway was also used to pull up supplies.

The mine worked only one shift. The lessees employed two miners, makin a total crew of four men.

About 200 tons of ore had been shipped during the year since September 1936, when operations at the lease began. The usual range of values in the ore shipped was: Gold, 1.5 to 2.0 ounces per ton; silver, 2 to 5 ounces per ton; lead, 5 to 12 percent. The average gross value of all shipments, except the last, before smelter charges, freight, and royalty (10 percent) wer deducted, was $42.00 per ton. The last shipment, a 20-ton lot, had a gross value of $72.00 per ton. Settlement figures for recent shipments were as follows:

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Total wet weight ..... tons	218.6	
Total dry weight ..... "	202.9	
Net value at smelter		$ 8,137.65
Freight	$213.74	
Haulage and sampling.	861.60	
Royalty at 10 percent	706.69	1,782.03
Net proceeds		$ 6,355.62

Plans were in progress to use an air drill in each stope. A stoping drill and a mounted jackhammer had been acquired, and a gasoline engine was being installed at the portal to drive a 10- by 10-inch air compressor.

Phillips Mine

The Phillips mine is on the south side of Buckskin Gulch, about 2 miles by road west of Alma. Information on the property was kindly furnished by Walter Snell, one of the miners. In September 1937 it was being worked under a lease agreement by the 2-3-4 Mining Co. Three men were beginning to drift southeasterly on a nearly vertical vein of lead ore at a contact of gray porphyry and quartzite. The vein had been found in an adit at a distance of 300 feet from the portal. It was about 3 feet wide and included 1 foot very rich in galena. Drilling was done with a drifting machine mounted on a vertical column. Air for drilling was supplied by a small compressor driven by a gasoline engine at the portal. The adit was equipped with a small mine car and 12-pound rails.

Before the above work was done a lower adit had been driven 265 feet during the summer. A 34-foot raise from the end of the adit had connected with old workings.

Silver Wave Mine

The Silver Wave property is on the north side of Buckskin Gulch about 2.8 miles by road from Alma. In September 1937 the mine was under lease to Wm. Casson & Co. An old upper adit that had caved in was being opened up by a timberman to enable miners to follow veins that had been exposed by old timers. The work had progressed 35 feet from the portal. According to James Riva, the timberman, who supplied the information on the property, two miners recently had been screening the mine dump. The fines were hauled to the Golden Cycle mill at Colorado City. They contained about $10 worth of gold per ton.

Excelsior Mine and Mill

The Excelsior property is on the north side of Buckskin Gulch. The mill is just off the main road up the gulch 2.6 miles from Alma. The mine is a quarter of a mile north of the mill on the south slope of Mount Bross. Both the mine and the mill were temporarily idle at the time of the visit in October 1937, but Nick Riggio was working the property intermittently

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with one helper, Louis Julian, who supplied the information on current operations. It was expected that the property would soon close on account of cold weather. Work in the mine consisted of following leads out of an old stope on the Paris level and in driving a drift on that level. Drilling was done by hand. The broken ore was hand-trammed 250 feet on the Paris level in a 1/2-ton scoop-and car and dumped down a vertical chute 100 feet to the level below. It was then trammed 50 feet to an inclined steel chute 350 feet long, which discharged into a hopper. From there the ore was trammed 200 feet to an ore bin at the upper terminal of a two-bucket gravity aerial tramway. The tramway conveyed the ore a quarter of a mile to a 75-ton bin at the mill.

The mill was equipped with irregular sizes of old machinery; all were driven from a line shaft by a steam engine. The flow sheet is shown in figure 17. The ore is fed by hand from the mill bin to a jaw crusher, from which it passes to a rod mill with a 10-mesh screen. The screen oversize is caught in a tub and shoveled back into the rod mill. The screen undersize passes over a short riffle and then to a Card table. The table tail is run out on the dump. The concentrate is shipped by truck to Leadville. A shipment of 7 tons of concentrates in August 1937 netted the operators $38 per ton.

Paris Mine and Mill

The Paris property is on the north side of Buckskin Gulch; it comprises a group of claims, including the Paris No. 2 E, Little Fannie, Helvetia, and Great West. The mill is on the main road 2.6 miles from Alma at an elevation of 11,003 feet. The mine is on the south slope of Mount Bross; it is connected with the mill by an aerial tramway 1,800 feet long. The property was visited on October 2, 1937. Fritz Keer was in charge and furnished the information on recent operations. Work had stopped September 21, 1937, with the expectation of resuming with a crew of 15 or 20 men as soon as finances would permit. There had previously been a crew of five men. Mining was confined to following nearly vertical quartz veins in sedimentary formations. There was about 2,000 feet of workings on the Paris level, whose main portal was at an elevation of 11,840 feet. A raise 26 feet high connected with the Great West workings. The upper terminal of the aerial tramway was 100 feet below the main portal of the Paris level.

A compressor room occupies one end of the mill building. Equipment includes a 10-drill compressor, belt-connected to a 150-horsepower motor. Compressed air had been used to operate four machine drills, a main hoist, and three tugger hoists in the mine.

Ore from the mine is lowered to a 30-ton bin at the mill by means of a two-bucket gravity aerial tramway 1,800 feet long; the vertical drop is about 700 feet. The last ore milled assayed 0.35 to 0.50 ounce of gold per ton. About 20 percent of the gold was free; the rest was locked up in the sulfides, mainly pyrite. A flow sheet of the mill is shown in figure 18.

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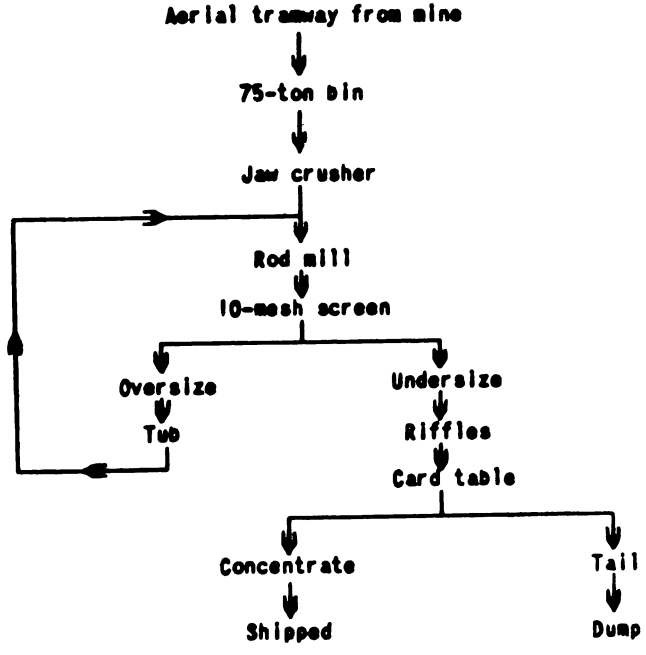

Figure 17.- Flow sheet of Excelsior mill.

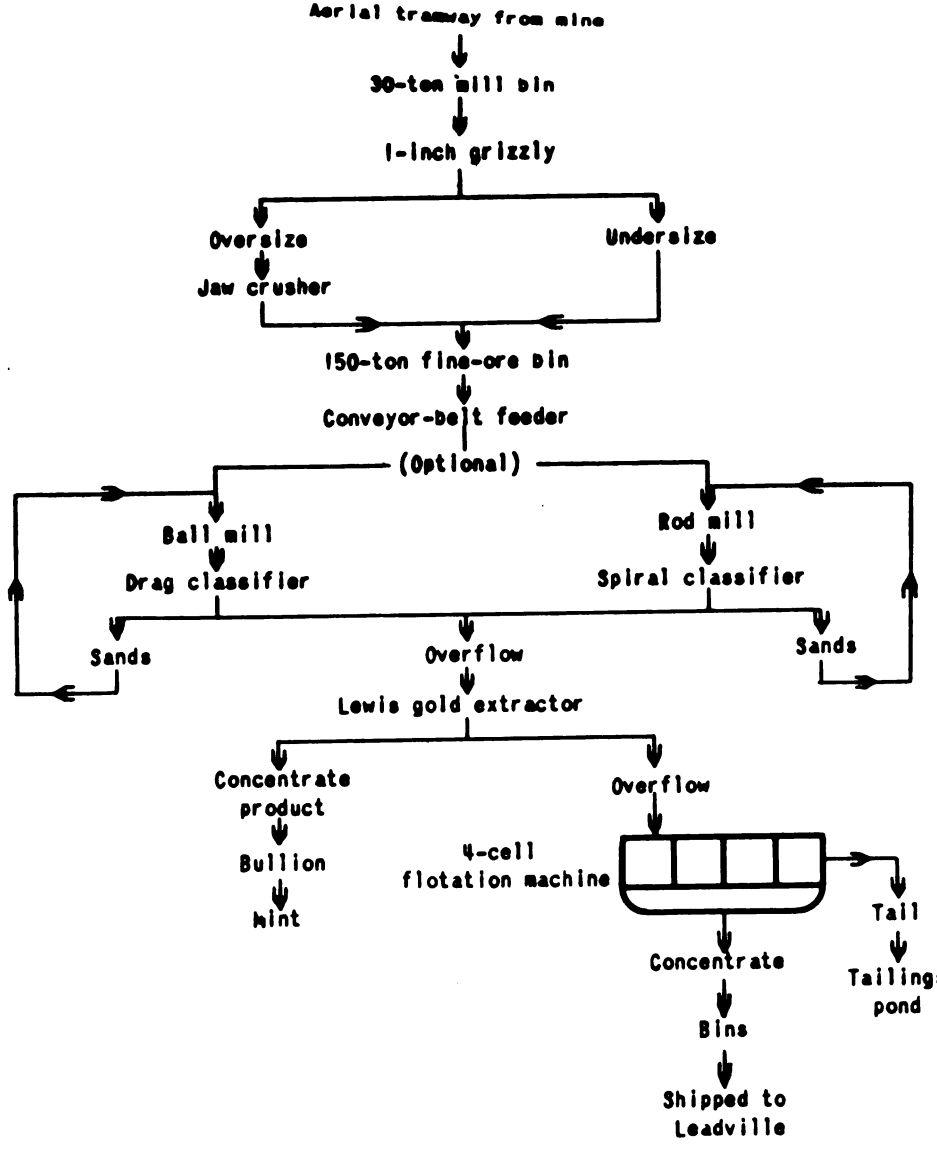

Figure 18.- Flow sheet of Paris mill.

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Ore from the tramway bin passes over a 1-inch grizzly. The oversize is fed to a jaw crusher, and the crushed ore joins the grizzly undersize in a 150-ton fine-ore bin. A conveyor belt feeds the fine ore either to a ball mill in closed circuit with a drag classifier or to a rod mill in closed circuit with a spiral classifier. The optional grinding circuit is to provide for treating different types of ores. The classifier overflow is treated with mercury in a Lewis gold extractor. The concentrate product, consisting of amalgam and some heavy minerals including gold, is retorted. The bullion is shipped to the Denver Mint. The overflow from the gold extractor enters the first cell of a four-cell flotation machine. All four cells make a concentrate, which is stored in a bin for shipment to the smelter of the American Smelting & Refining Co. at Leadville. Flotation concentrates contain 4 to 5 ounces of gold per ton and a little silver. The flotation tails are discharged into a tailings pond.

Sonny Boy Claim

The Sonny Boy claim is at the head of Buckskin Gulch. In September 1937, Hiner and a part-time helper were advancing an adit by hand drilling. According to Hiner, the adit followed the Iowa vein; it was in about 450 feet. The sorted ore usually contained about 0.28 ounce of gold, and 11 to 40 ounces of silver, per ton. A small shipment had been made during the summer.

Sweet Home Mine

The Sweet Home property is on the north side of Buckskin Gulch, 4.1 miles from Alma. According to the caretaker the property has been idle since 1931. High-grade ore from the mine was formerly sacked; milling grade ore has been stored in a dump.

Lone Jack Molybdenum Co.

In September 1937 the Lone Jack Molybdenum Co. was conducting exploration work along the granite ridge and flanks of Mount Democrat at an altitude of about 13,000 feet. Operations were under the direction of J. N. Redman of Denver, Colo.; J. Price Briscoe of Fairplay kindly contributed the information that follows:

Float carrying molybdenite was traced 1,800 feet along the ridge. Trenching at about 10 places had disclosed a 20-foot zone of veinlets one-eighth inch wide carrying molybdenite. Over the 20-foot width assays showed 2 to 6 percent MoS_2. Preparations were being made to get under the slide rock to drive a crosscut. Consideration was being given to a plan for extending the Kentucky Belle adit, near the head of Buckskin Gulch, about 1,000 feet to cut the molybdenite zone. Company operations are about 2 miles from the mine of the Climax Molybdenum Co.

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Alma Syndicate, Inc.

The mine and mill of Alma Syndicate, Inc., are on the east flank of Mount Bross. The elevation of the mill is 11,700 feet; that of the mine, 12,700 feet. They are connected by an aerial tramway. Acknowledgment is made to N. P. Otis, president, and J. L. White, general superintendent, for information on the mine.

The ore bodies occur in quartzite lenses in limestone that roughly parallel the topography. The ore is 4 to 8 feet thick; the overburden, 1 to 4 feet thick. Gold occurs free in quartz; silver is present mainly as argentite. The gangue is principally quartz with some limestone and porphyry. Thirty thousand to 50,000 tons of ore have been developed by test pits. The estimated value of the ore is $13 per ton, gold contributing 40 percent and silver 60 percent of the total value.

Mine

At the mine there is a combined bunk house and boarding house, and a compressor house. A five-drill V-type compressor driven by a 65-horsepower motor supplies air for drilling at 75 pounds per square inch. The air from the compressor passes through a 3-inch pipe to a 4- by 12-foot receiver. A short 2-inch air line is followed by a 1-inch line to the working places.

Mining is done on one shift. In early October 1937 the ore was being blasted down along the strike of two lenses, one about 30 feet above the other. From the lower level an untimbered crosscut adit had been driven about 100 feet. It will be extended, and raises will be driven from it into which the ore from the upper bench will then be mill-holed. Surface drilling was done with jackhammers, using 7/8-inch hollow hexagonal steel. Drilling in the adit was done with a drifting machine using 1-inch hollow round steel. A stoper with 1-inch hollow quarter-octagon steel is available for raising. Detachable bits are used with the jackhammer and drifter drills. Starting bits are 2-1/4 inches in diameter; following sizes decrease by 1/8 inch. Water for drilling is hauled from a nearby creek; it is used in pressure tanks.

In October 1937 surface mining was done by advancing the bench in a general way up the strike. The width of the bench along the strike was divided into several working places. While drilling was in progress in one working place, another was being cleaned up. Ten to 20 shallow holes were drilled in a shift; they were spaced and pointed to fit the ground. One or two sticks of 40-percent-strength gelatin dynamite ordinarily were used in each hole; they were fired by fuse and cap. The ore and overburden were blasted separately when possible. Waste was piled to one side and left. Broken ore was thrown or shoveled into 1/2-ton or 1-ton mine cars, which were brought to the working places over a track of 8-pound rails; the gage was 18 inches. The ore was hand-trammed a few hundred feet and dumped into either a chute that conveyed it directly to a crushing plant or a chute from which it was retrammed to the crushing plant. There was a 12-inch grizzly at the top of each chute. In October 1937 there were 20 men at the mine -

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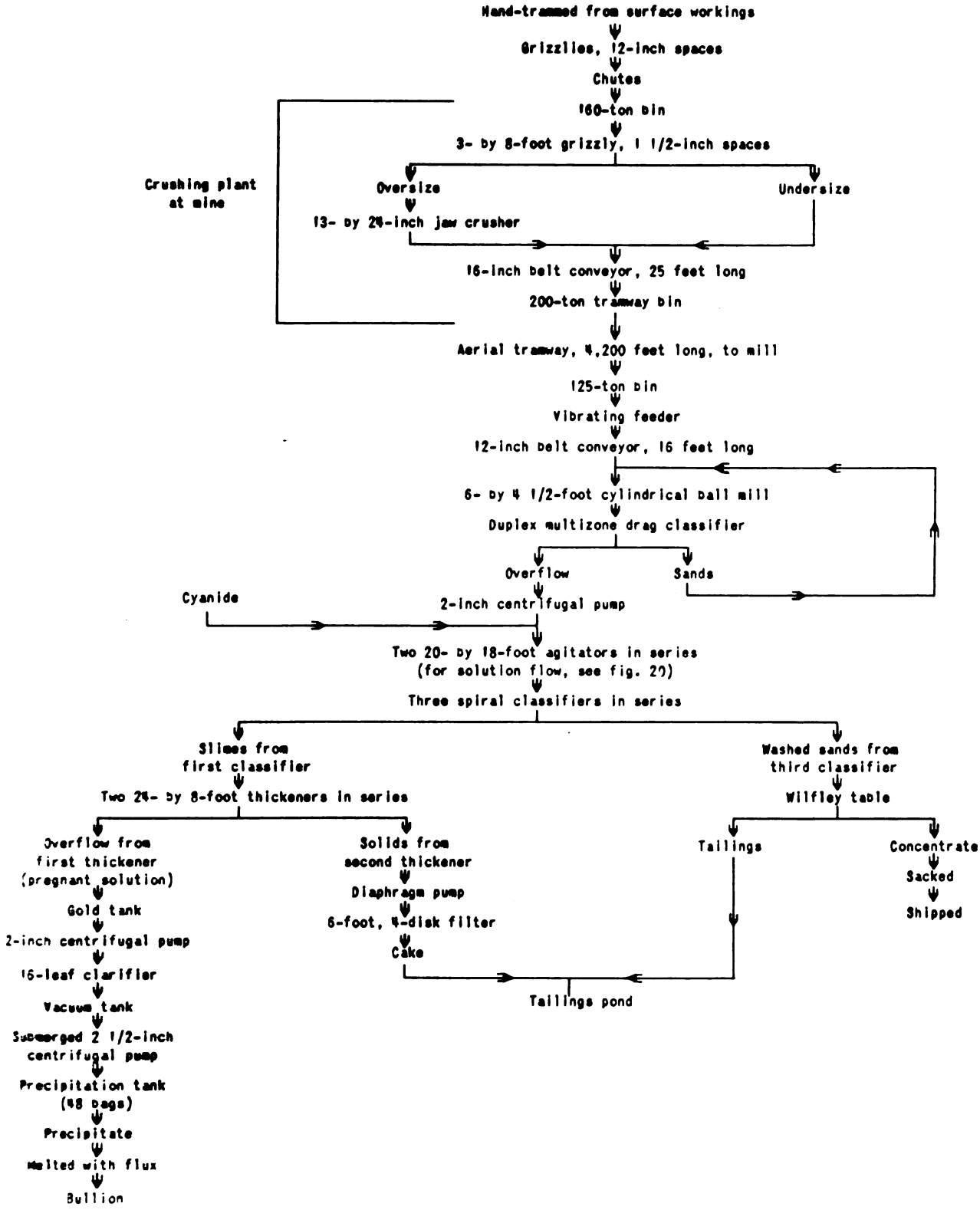

Figure 19.- Flow sheet of crushing plant and mill, Alma-Syndicate, Inc. (For solution flow, see fig. 20.)

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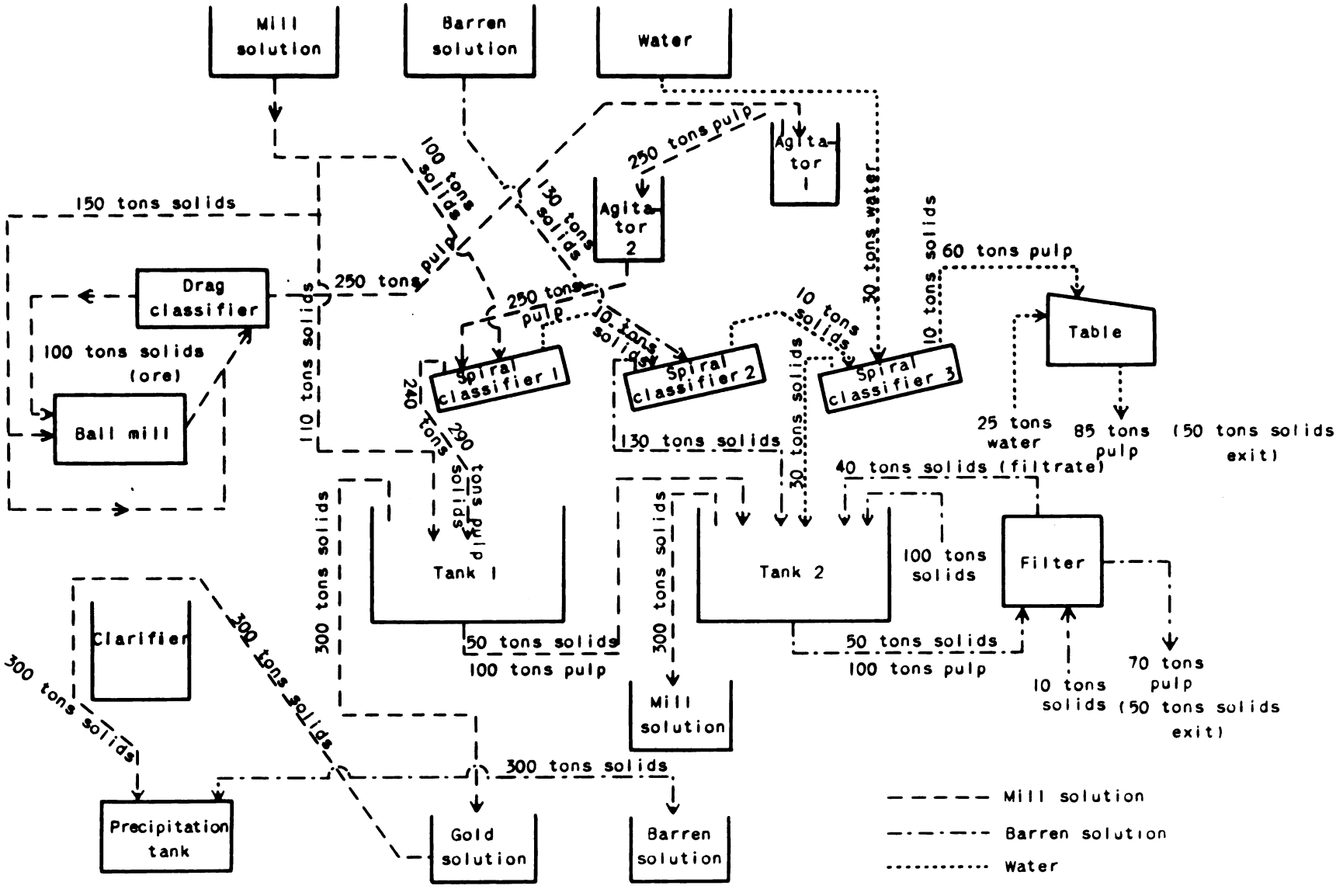

Figure 20.– Solution flow sheet of Alma Syndicate mill for 100 tons of ore, precipitating 300 tons of solution per day. Pulp ratio, 1 1/2 : 1.

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1 foreman, 3 machine men, 13 shovelers and trammers, 1 blacksmith, 1 cook, 1 man loading buckets on the aerial tramway. Wages ranged from $4 to $5 per day.

Crushing Plant

A flow sheet of the crushing plant is shown in figure 19. At the head of the plant is a 160-ton bin which receives the ore from the mine, as previously described. The ore from the bin passes over a 3- by 8-foot grizzly with 1-1/2-inch spaces between the bars. The oversize is fed to a 13- by 24-inch jaw crusher set at 1-1/2 inches and driven at 350 r.p.m. by a 40-horsepower motor. A 16-inch belt conveyor 25 feet long carries the crushed ore and the grizzly undersize up a slight grade to a 200-ton loading bin at the upper terminal of an aerial tramway. The tramway is 4,200 feet long; it is equipped with twenty-one 500-pound buckets that travel at 250 feet per minute. The drop is about 1,000 feet.

Mill

The Alma Syndicate mill is a 100-ton sand-slime cyanide unit; it is the only cyanide plant in the district. This type of mill was decided upon as a result of tests; flotation experiments were not successful. On August 13, 1937 it began operating one shift per day; when visited the following October it was operating three shifts and treating 100 tons per day. E. H. Speiser, mill superintendent, kindly contributed the information on mill operations. The flow sheet is shown in figure 19. The aerial tramway transports the crushed ore from the crushing plant to a 125-ton bin at the head of the mill. The ore contains about 0.16 ounce of gold and 8 to 10 ounces of silver per ton; it is hard, owing to the quartz. Moisture in the heads is about 5 percent.

A vibrating feeder delivers the ore from the bin to a 12-inch belt conveyor 16 feet long, which carries it up a 10° slope to a 6- by 4-1/2-foot cylindrical ball mill driven at 25 r.p.m. by a 100-horsepower motor. The ball load is 9,000 pounds; 4-inch balls and liners of manganese steel are used. The ball consumption is 2.7 pounds per ton of ore. The ball mill grinds about 4 tons of ore per hour to minus 32-mesh. The discharge from the ball mill enters a duplex multizone drag classifier, the sands from which are returned to the ball mill. The circulating load is 500 percent; the pulp density of the load is about 2.00. The classifier overflow contains 40 percent solids; the density is usually between 1.32 and 1.36. It is pumped by a 2-inch centrifugal pump to the first of two 20- by 18-foot agitators in series. Cyanide is added at No. 1 agitator; the solution strength used is 2 pounds of cyanide per ton. Lime is added to maintain the protective alkalinity of the solution at 1 pound per ton. The agitators are driven at 150 r.p.m. by individual 15-horsepower motors. Figure 20 shows the flow of solutions and pulp through the cyanide circuit. The total treatment period is 36 hours. The agitated pulp (250 tons per day) enters the first of three spiral classifiers in series. The sands, representing 50 percent of the solids or 50 tons per day, are washed in the first spiral classifier with 100 tons of mill solution; in the second classifier, with

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130 tons of barren solution; and in the third classifier, with 30 tons of water. The washed sands discharged by the third classifier are treated on a Wilfley table; the use of this table is experimental. The table concentrates assay about 30 ounces of silver and about 0.4 ounce of gold per ton; they are sacked for shipment. The tails flow to the tailings pond, a large basin behind a natural dam that will hold tailings for many years.

The overflow from the first spiral classifier amounting to 50 tons of solids per day, carries all the slimes that are produced to a 24- by 8-foot thickener, tank 1 in figure 20. The underflow is pumped by a diaphragm pump to a second 24- by 8-foot thickener. This thickener also receives the wash solutions from the second and third spiral classifiers. The overflow from the second thickener is pumped to the mill-solution tank; it amounts to 300 tons of solution per day. The underflow from No. 2 thickener is pumped by a diaphragm pump to a 6-foot four-disk filter. The cake is washed with barren solution and discharged into the tailings pond. The filtrate is returned to No. 2 thickener.

The pregnant solution that overflows from No. 1 thickener flows into a gold-solution tank from which a 2-inch centrifugal pump delivers it to a 16-leaf clarifier; the leaves are 6 by 6 feet. The solution then passes into a vacuum tank where it is deaerated by a vacuum pump. A submerged 2-1/2-inch centrifugal pump delivers the solution from the vacuum tank to a precipitation tank. Zinc dust, in the amount of 0.3 pound per ton of ore, is fed into the line between the vacuum tank and the pump. The precipitation tank contains 48 double bags - a muslin bag within a canvas bag. Bags are periodically removed and washed. The precipitate is melted with a suitable flux and the gold bullion cast into bars that are sent to the Denver Mint. The fineness of the bullion is about 700 in silver and about 17 in gold. The recovery of gold is about 95 percent; of silver, about 80 percent. Tails assay 0.9 to 1.2 ounces of silver per ton and a trace of gold.

Solution data:

NaCN to be added to bring solution to 3 pounds per ton	pounds	1,811
NaCN to be added daily	pounds per ton	1.02
$Ca(OH)_2$ to be added to bring alkalinity to 1.5 pounds per ton	pounds	1,020
$Ca(OH)_2$ to be added daily	pounds per ton	5.50

Power:

Power consumption in horsepower, is estimated as follows:

Mine power	80
Mill power	130

Electric power for operations costs a little less than 2 cents per kilowatt-hour.

Most of the water used for milling is obtained from a nearby tunnel; the remainder is piped from a small spring.

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Mill heads are sampled by hand at both terminals of the aerial tramway. Concentrates are sampled by hand in the concentrate bin. Tailings are sampled by hand every half hour at the Wilfley table and at the filter. A continuous sample is taken of the barren solution and of the gold solution at the clarifier. Other solutions and pulps are sampled once a day.

Daily mill labor comprises one superintendent, three operators, three helpers, one clean-up man, and one assayer. Half of the time of one blacksmith, one carpenter, and one electrician is charged to the mill; the other half is charged to the mine.

Barcoe Tunnel

The Barcoe tunnel was driven into the north end of Sheep Mountain in a southerly direction, with the object of crosscutting the London fault. The portal of the tunnel is about 5 miles southeast of the London mine. It is reached from Fairplay via State highway No. 8 for 0.4 mile, then westerly for 7.8 miles up Fourmile Creek. On September 25, 1937, the tunnel was about 1,800 feet long. The information on operations was kindly contributed by Sid Gately, superintendent.

At the tunnel portal a small, V-type compressor was driven by a portable gasoline engine. Air was delivered to a 4- by 12-foot receiver at 110 pounds per square inch. A 3-inch air line carried the air into the tunnel for 1,000 feet, beyond which a 2-inch line was used. At the portal was also a blacksmith shop equipped with a drill sharpener.

The tunnel is 5 by 8 feet in section, most of it untimbered. At the portal are about 50 sets of timber; there are 14 sets about 1,200 feet in the tunnel and 10 to 12 sets at other places. Tunnel sets, where used, are of 8- by 8-inch timbers placed on 5-foot centers; they are usually lagged.

The work of driving the tunnel was done on two shifts by a crew of nine men on contract. The crew comprised two drillers, four muckers, two trammers, and one blacksmith. Drilling was done by a drifting machine mounted on a horizontal bar. The type of round usually drilled was a 13-hole bottom-cut round, consisting of 1 back hole, 3 breast holes, 3 relief holes, 3 cut holes, and 3 lifters. All but the lifters were drilled from the upper position of the bar. Four lengths of conventional steel were used; steel for the cut holes was 7 feet long. Starting bits were 2-1/4 inches in diameter; followers decreased by 1/8 inch. Water for drilling was collected near the middle of the tunnel and put into a pressure tank, from which it was delivered to the face through a 3/4-inch pipe. About 50 pounds (125 sticks) of 40-percent-strength dynamite was required for a round. Primers were 45-percent-strength gelatin dynamite. Electric blasting caps in five delays were used; they were fired by an electric blasting machine. A round broke about 4 feet. Steel shoveling sheets were used. The broken rock was shoveled into 20-cubic-foot end-dump mine cars. A 4-foot round broke about 15 cars of rock, which were hauled out singly by a mule. The mule brought each empty car back to a turnsheet a short distance from the face, from which point the muckers pushed it to the face. The track rails were 12-pound; the gage, 24 inches.

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The tunnel was ventilated by a centrifugal blower at the portal, which exhausted the gases from the face through a 10-inch sheet-iron pipe. The blower was driven by a small gasoline engine.

Carbide lamps were used for lighting.

PLACER MINES

The Alma district includes a considerable acreage of placer ground, but the value of the gold produced from placer operations is relatively unimportant compared to that produced from lodes. The most extensive deposits that have been mined were in the glacial moraines south of Fairplay. Several deposits of value have been mined in the glacial till east of Alma. Beaver Creek and some of the gulches on the east slope of the Mosquito Range have also yielded placer gold.

Snider Placer

In October 1937 Ben Snider and F. M. Smith were working a placer deposit known as the Snider placer across the South Platte River from Alma. The ground was leased from Cary W. Rhodes, owner. Information on the operation was kindly furnished by Smith.

The upper 12 feet of gravel had been stripped with a power shovel and discarded. In October 1937 a pit 25 feet deep had been excavated; the bottom was on bedrock. Two men, working on bedrock, shoveled from the bank into two 12-cubic-foot mine cars. Track was of 8-pound rails; the gage was 18-inch. Loaded cars were pulled singly up an incline about 200 feet long by an old dragline engine equipped with 3/4-inch wire rope. At the top of the incline the engine operator dumped the car into a trommel with 13/16-inch holes, driven by an old automobile engine. The oversize, after being inspected for nuggets, was dumped for waste. The trommel undersize was run over an 18-inch Hungarian riffle and then over a 3/4-inch woven-wire screen supported on metal lath; the lath was laid on canton flannel. One man operated both the hoisting engine and the trommel.

From 20 to 25 cars of gravel were screened per day. The riffles caught about 3 pounds of concentrate per day. This was panned down to about 1-1/4 ounces of gold. The operators estimated the gold content of the gravel as mined to be 1 pennyweight per car.

Richards Placer

The Richards placer is on the east bank of the South Platte River across from Alma and just south of the Snider placer. In October 1937 it was being worked by Jack Richards and C. R. Hustead under a lease agreement from Cary W. Rhodes, owner; the royalty was 25 percent. Information on operations was kindly given by Richards. The ground embraced in the lease had been worked by former operators to a depth of about 35 feet, which was only halfway down to bedrock. In October 1937 the bottom 35 feet of gravel and 2 to 6 feet of bedrock were being mined.

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Two shifts were worked, 10 to 12 men on each shift. The labor per shift comprised the following:

	Per day	
1 shovel operator	$ 5.00	
1 oiler in pit	7.00	
1 trackman	5.00	($4.00 at night)
1 horse driver	5.00	do.
1 flagman	5.00	do.
1 truck driver for tailings	5.00	
1 hoistman	5.00	
1 washer on trommel	5.00	
1 car dumper	5.00	
1 oiler in trommel house	5.00	
1 roustabout	100.00	per month

Mining was done by a gasoline shovel on bedrock; it was mounted on crawler treads and was equipped with a 3/4-yard dipper. The shovel took longitudinal cuts 3 feet deep the full length of the pit and as wide as the boom would permit; the pit was two cuts wide and about 300 feet long. The excavated gravel and bedrock were loaded into 3-cubic-yard steel coal cars. The usual carload was three dipperfuls and averaged 2 cubic yards. Track was laid lengthwise through the center of the pit; 20- and 40-pound rails were used and the gage was 3 feet. The shovel sorted out boulders and dumped them to one side; they had to be rehandled in making the adjacent cut. An average of 110 cars was loaded in a shift; the day shift loaded a total of 600 cars during the first 5 days of October 1937.

Seepage water was pumped from the bottom of the pit by a 2-inch centrifugal pump which relayed it to a centrally located 4-inch pump. The latter raised the water over the edge of the pit and into the South Platte.

When a pit car had been loaded by the shovel it was pulled by a horse about 200 feet to the foot of a 20° incline 300 feet long, which led out of the west side of the pit. A 50-horsepower hoist at the head of the incline pulled the cars singly out of the pit. They were dumped into a hopper and returned to the pit; the horse pulled them back to the shovel.

The gravel is washed through the hopper into a trommel having a scrubbing chamber 16 feet long followed by 10 feet of screen. Most of the screen openings are 1 inch; some are larger. The trommel is driven by a 25-horsepower motor. The oversize is caught in a truck, which dumps it over a waste dump. The undersize is delivered to a 3- by 30-foot sluice. The riffles in the first 8 feet of the sluice are formed by an old jail door. The bars are 2 inches in diameter; they are 4 inches apart both across and lengthwise of the sluice. The door is laid on cocomatting; under the matting is a carpet. About 90 percent of the recovered gold is caught in the first 8 feet. The next 20 feet of the sluice is equipped with wooden riffles over coco matting and carpet. The riffles are 2 inches high and 2 inches apart; they slant backward slightly. Mercury is used in all the riffles. The last

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2 feet of the sluice is a mercury trap formed by 3-inch squares of 1-1/2-inch iron bars. About 20 pounds of mercury is used on the sluice, most of it in the trap. The loss of mercury is negligible.

From 100 to 140 ounces of gold were recovered in a week. Average recovery was estimated to be 9 ounces per shift. A recent assay of the bullion showed the gold to be 833 fine; the button contained 11 percent silver. The retort bullion is sold to the Denver Mint through the bank at Fairplay.

R. & W. Co. Placer

(Known also as Phillips' placer)

In July 1938 the pit on the ground previously described (see p. 59) as the Snider lease was extended southward by R. S. Wilford and A. F. Reesman, operating under the name of the R. & W. Co. Information on their operations was kindly supplied by Wilford, manager, and by Phillips, mine foreman.

Excavation was done by a 1-yard Diesel shovel working at the base of a bank 25 to 30 feet high. The shovel loaded the gravel into a 5-1/2-yard Dumptor[12/] and a 2-yard truck; a second 2-yard truck was used when digging was easy. The excavated gravel was hauled about 500 feet up a 6-percent grade to a washing plant. A round trip, including loading and dumping, required about 5 minutes. At the washing plant the gravel was dumped through a 12-inch grizzly into a hopper. A man with a hose flushed the gravel through the hopper and into a 48-inch by 34-foot trommel. A 25-horsepower, 440-volt motor drove the trommel at a speed of 11-1/2 r.p.m. The first half of the trommel was provided with 1-inch holes; the second half, with 1-1/4-inch holes. The trommel oversize passed onto a 24-inch belt conveyor 30 feet long, which elevated the material about 10 feet and dumped it in a pile. The conveyor was driven at a speed of 125 feet per minute by a 5-horsepower motor. A bulldozer, working intermittently, spread the pile of coarse material discharged by the conveyor over a radius of about 150 feet. At other times the bulldozer was used to smooth the roadway in the pit.

The trommel undersize was delivered to a 60-inch sluice 33 feet long having a slope of 1 inch per foot. Riffles were made of 1/4-inch steel straps 1-1/2 inches high spaced 1-3/4 inches apart. They were set at an angle of 45°, sloping downstream, and were welded to side pieces in 3-foot sections. This sluice was followed by another 60-inch sluice 16 feet long, on the bottom of which was a carpet covered with 1/2-inch wire screen.

The first 3 feet of the first sluice was cleaned up every 12 hours; the next 6 to 10 feet was cleaned up every 24 hours; the remaining sections were cleaned up every 10 days. The concentrate was shoveled into tubs and

12/ A vehicle with very large front wheels and a hopper shaped body which dumps forward. The driver sits at the rear. It is locally called a "go-devil".

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then put over an 8-inch sluice. The cleaned concentrate was hand-panned with mercury and the amalgam retorted. The resulting bullion was about 828 fine. The plant uses 1,200 gallons of water per minute; the pressure head is 40 pounds per square inch.

In June 1938 the mine worked three 8-hour shifts per day. The operating (washing) time was 420 hours, or 58-1/3 percent of the total time. During the month 24,625 cubic yards of gravel was excavated and washed, or 58.6 yards per hour of operation. That yardage yielded 31 cents net per cubic yard, after 25-percent royalty paid to Cary W. Rhodes, owner, had been deducted. The operators received about $28 an ounce from the Denver mint for the bullion; $7 an ounce was paid for royalty, leaving $21 an ounce for costs and profit.

The labor employed per shift comprised:

1 shovel operator.....	$1.00 per hour
2 truck drivers	.50 per hour
2 hopper men	.50 per hour
1 trommel man	.50 per hour
1 bulldozer operator	5.71 per day

In July 1938 two 10-hour shifts were substituted for the three 8-hour shifts previously used. A recent daily expense report is shown in table 17.

The operators hold the opinion that the present equipment should handle 1,200 cubic yards per day. The ground being worked is believed to assay 41 cents per cubic yard, indicating a recovery of about 80 percent, based upon the above daily report.

Logue Placers

In July 1938, C. L. Logue was drift-mining in the placer gravel between the Richards lease and the R. & W. Co. lease. Acknowledgment is made to Logue for information on his operations. Underground workings comprised about a mile of drifts. The average value of the gravel mined was $4 to $5 per cubic yard; some of the ground is worth as much as $18 per cubic yard. Gravel valued at less than $3 per cubic yard is not mined.

A force of six men was working, two men on each of three shifts. Drifts were advanced by hand-picking; no powder was used. Some wheelbarrow work was done on restricted workings, but most of the gravel excavated was loaded into a 14-cubic-foot car and trammed about 400 feet to the bottom of a slope near the portal of the diggings. From 6 to 8 cars, holding 3 or 4 cubic yards, were trammed out each shift. A 15-horsepower hoist at the portal pulled the car up a short 17° slope to the pit on the Richards lease. The gravel bank above the portal is 50 feet high; it assays 26 cents per cubic yard.

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TABLE 17. - Daily expense report, R. & W. Co.

Daily gross payroll	$ 110.00
Social security tax	5.50
Manager's salary	6.67
Foreman's salary	6.67
Gasoline	24.00
Oil	8.00
Grease	3.00
Electric power	15.00
Repairs	20.00
Compensation insurance	6.00
Depreciation	16.00
Telephone and postage	1.00
Freight and express	2.00
Miscellaneous	10.00
Truck rental	20.00
Total cost for day	$ 253.84
Estimated:	
Net mint receipts	$ 400.00
Profit for day	146.16
Total cost per hour	10.58
Total cost per yard	.21
Number of hours operating	20
Number of cubic yards washed	1,200
Gold per yard	$0.33
Profit per yard	.12

The gravel was dumped into a bin, from which it was fed to a 3-by 12-foot trommel with 1-inch holes. The trommel undersize passed over a 10-inch by 8-foot sluice having a slope of 1-1/2 inches per foot. Riffles were of 3/4-inch angle iron; they were laid on expanded metal lath which rested on a rubber bottom. Operators estimated their net profit at about $1 per pennyweight of gold recovered.

Beaver Creek Placer Corporation

In October 1937 the Beaver Creek Placer Corporation was operating a dragline on Beaver Creek, about a mile north of Fairplay. Information on their operations was kindly supplied by H. H. Reiber, who was in charge. Operations in the fall of 1936 have been described by Gardner and Allsman.[13/]

13/ Gardner, E. D., and Allsman, Paul T., Power-shovel and Dragline Placer Mining: Bureau of Mines Inf. Circ. 7013, 1938, p. 11.

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The dragline was equipped with a 70-foot boom and a 2-1/2 cubic-yard bucket. It worked from the top of the bank, which was being advanced up-stream; the creek had been diverted. The gravel was about 40 feet deep; it was excavated to a depth of 31 feet, leaving the bottom 8 to 10 feet of gravel on bedrock. The bedrock was red sandstone. Water in the pit was 20 feet deep and apparently interfered with proper digging of the bucket. Large boulders also interfered. The dragline could dig at the rate of 1,000 cubic yards per shift but averaged about half that amount.

The dragline bucket dumped into a hopper on the up-stream end of a floating washing plant in the pit. The hopper delivered the gravel to a 4-1/2- by 28-1/2-foot trommel. The first part of the trommel had 1/2-inch holes, the central part had 3/4-inch holes, and the last part had 1-1/4- by 3/4-inch slots. On each side of the trommel were eight 2- by 9-foot sluices and one 4- by 28-foot sluice. On the bottoms of the 9-foot sluices was a 3/4-inch screen over coco matting. On the 28-foot sluices, T-riffles 1 inch high were used. About 85 percent of the recovered gold was caught in the first 6 feet (our boxes) on both sides. A tailings stacker about 50 feet long discharged the oversize from the trommel into the area behind the washing plant. A clean-up was made weekly. The usual recovery was about 25 ounces of gold from 16 hours of actual operation.

Three men constituted the crew - one dragline operator at $7 per day and two men on the washing plant at $5 per day.

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